

Environmental surveys, management and land degradation in the Murrumbidgee river catchment



A project funded by Friends of the Five Forests

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Cover photographs

Left - Aerial view of the Murrah river below the junction with Knights creek

Top right – Shotgun damage to trees

Bottom right – Knights creek during a moderate flow

Introduction

The most recent Federal State of the Environment report indicates “Overall, the state and trend of the environment of Australia are poor and deteriorating as a result of increasing pressures from climate change, habitat loss, invasive species, pollution and resource extraction” and “Our inability to adequately manage pressures will continue to result in species extinctions and deteriorating ecosystem condition, which are reducing the environmental capital on which current and future economies depend. Social, environmental and economic impacts are already apparent.”

Consistent with these national concerns, the evidence confirms an inability of state and local governments to adequately manage remnant native forests in the Murrah river catchment, with climate change adding to the existing pressures from habitat loss, invasive species, pollution and resource extraction.

An ability to address the negative impacts of environmental mismanagement requires both an adequate understanding of the threats and adaptive management systems designed to mitigate them. The ongoing absence of this understanding has long-term implications as the environmental threats become intractable and beyond any human capacity to mitigate them.

Background

Despite objections from most of the local community, in 1998 the Bermagui Field and Game shotgun club (the club) received Bega Valley Shire Council (BVSC) approval to operate a shooting range. The location is on a previously forested property in the lower reaches of the Murrah river catchment and habitat for the last koalas on the New South Wales far south coast.

A fauna and flora assessment was undertaken for the club within area of 100 x 200 metres (2 hectares) upslope of where unapproved shooting was being conducted at the time (Southern Ecological Services, 1997). The assessment didn't identify the forest ecosystem/s on the site (Keith and Bedward, 1994) but did include a koala call-back survey, that did not detect koalas. This outcome could well be a consequence of the timing of the survey, that was undertaken in June. Male koalas are more likely to call and respond to call-back surveys during the breeding season, October and November (Law et al, 2020).

The assessment indicated:

“ Although no evidence of koalas was detected during the surveys, the proximity of records to the west makes it likely that koalas may pass though the site and may be disturbed by intermittent noise.”

Based on koala feed tree species listed in Schedule 2 of State Environmental Planning Policy, the assessment concluded “core koala habitat does not exist at the site”. In August of the same year, a report on koala surveys undertaken by the South East Forest Conservation Council (Phillips, 1997) defined koala's preferred tree species in Murrah and Bermagui state forests. Murrah state forest is immediately adjacent to the shooting range. These surveys found koalas were utilising three of the four eucalyptus tree species identified during the flora and fauna assessment.

However the NPWS apparently had no concerns, but repeated SES suggestions that no trees should be removed.

Murrah and Mumbulla State Forests are on the north and south side of the Murrah river respectively and both forests were included in a 2001 nomination to list the resident koalas as an endangered

population. The NSW Scientific committee's 2007 determination to reject the nomination indicated:

"Koalas in the nominated population area are not near the limit of the species' geographical range. They are neither genetically, morphologically nor ecologically distinct, nor is the nominated population area of significant conservation value relative to other populations of the species in NSW." and "The quality of Koala habitat in this area is deteriorating because of multiple factors including extensive canopy dieback, clearing due to rural-residential development and commercial forest harvesting. Koalas currently occur at a low density in southeast NSW including the nominated population area."

No other low density koala populations have been identified in coastal forests of southeast NSW since 2001.

In 2012 the shotgun club subdivided and purchased an area of 24 hectares from the landowner, that did not include all the areas where shooting had been undertaken for the previous 15 years. This new subdivision included the area where the flora and fauna assessment was undertaken. Subsequently, a modified development application to increase shooting days from one to two days a month was submitted to BVSC.

In 2016 Murrah and Mumbulla state forests were reclassified as 'Flora reserves', that require a decision of the NSW government to enable further logging. In 2017 a report on the results of a scat-based analysis of koala sex, genetic diversity and infection status was released (Higgins et al, 2017). The analysis found koalas in the area are genetically distinct and *Chlamydia pecorum* was detected in koalas north of the Murrah river, but not in koalas south of the Murrah river.

The report recommended:

- o Considering the need for expansion of this population, and the impact of *Chlamydia* on fertility, the risk of introduction of *Chlamydia* to this population should be a priority consideration in management planning.
- o It would be of interest to compare the Mumbulla and surrounding *Chlamydia* positive populations to assess their relative health and viability.
- o It would be of interest to examine animal movement between the Mumbulla and Murrah SF populations to assess potential for chlamydial introduction and also population connectivity.

To date there is no evidence to demonstrate any surveys have been undertaken to develop an improved understanding of whether the noise from the club reduces the area of koala habitat (Kinsella, 2014), or has an influence koala movement, or the lack of it, between Murrah and Mumbulla SF.

Along with other concerns and comments during their community consultation on the proposal to increase shooting. BVSC was provided with a detailed appraisal of the Modification Application from Town planning, Agricultural and Environmental consultants Cowman and Stoddart Pty Ltd (Richardson, 2019). The appraisal highlighted legal precedents conflicting with advice from BVSC's planning department to BVSC, that despite doubling the number of shooting days, the modification 'will remain substantially the same as the development that was originally approved'. With regard to environmental concerns the appraisal indicated -

" . . . The site is situated within the catchment of the Murrah River and Lagoon. Clearly any proposal that seeks to double the number of days when shooting will occur at this site will result in the doubling of the amount of lead and other contaminants that will impact the site and potentially the surrounding environment.

No detailed assessment supports the Application with respect to this issue. Council staff's report suggests that the Applicant has (subsequently) undertaken some water and soil analysis. This information was not included with the original application. It would appear from Council's staff's assessment report that this assessment may not be a final document (it was apparently unsigned) and does not provide a detailed assessment addressing; the extent to which the land may be already contaminated; that confirms that it will be suitable for the proposed intensification of operations; and if it is contaminated whether it requires to be remediated for its continued use. In the absence of such an assessment the Application should be refused.

The issue of contamination and remediation raises a further important issue with the future responsibility for the remediation of the subject land once the existing shooting range operations cease. This should be a matter of serious concern for Council (and potentially the NSW Government) with this Application which seeks to substantially intensify shooting activities at the site and which therefore has the potential to substantially increase lead and other contamination of the site and surrounds (including local waterways). The Application however does not demonstrate:

- ⌚ that the terrain of the site would allow recovery of lead and other contaminants;
- ⌚ That dissolved lead and other contaminants will not enter local waterways and its sediments including the Murrah River and Lagoon;
- ⌚ Financial assurances either by a Deed or Agreement and / or Bank Guarantee from either the Club or landowner demonstrating that sufficient financial resources are available to ensure that the subject site will be able to be remediated following the cessation of the clubs activities."

Following a soil analysis report from the Murrah River Action Group (MRAG), in 2019, BVSC sought advice from the NSW Environment Protection Authority (EPA). In its advice (Attachment 1), the EPA suggested BVSC advise the proponent to "engage a consultant to conduct a baseline contamination study at the site." (the study)

Among other concerns subsequently raised with regard to the study's apparent deficiencies. BVSC was provided a detailed assessment focused on the design and conduct of the study (Coiera. 2021). The assessment highlighted significant uncertainties with regard to the sampling method, the statistical assessment and the linkage assessment. The latter being the factors that would increase the potential for pollution to migrate from the site.

The assessment indicated-

" . . . There are a large number of major methodological problems identified in the ERM study in relation to where and how much data were collected, how they were statistically analysed, and how contamination pathways between on- and off-site locations were excluded.

As it stands, there appear to be many major questions over the conclusions drawn by the ERM study. Simply re-analysing the data would not remedy the fundamental problems with the data sampling strategy."

Based largely on claims from BVSC staff, that the Modification Application was the same as the initial Development Application, support for the study from the EPA and approval from the National Parks and Wildlife Service (NPWS), indicating appropriate koala surveys were not required. The newly named Bermagui Sporting Clays shotgun club received conditional BVSC approval for the increased shooting days. Local government approval for shooting ranges or changes to them, is a requirement of the NSW Police.

The baseline contamination study

In order to achieve Council approval for the increased shooting, Environmental Resources Management Australia Pty Ltd (ERM) was engaged by Sporting Clays NSW and/or, as indicated on study images, the NSW Field and Game Association Inc, to undertake a baseline study. ERM is accredited to undertake contamination assessments under the NSW Contaminated Lands Act.

The study indicates-

“ . . . The overarching objectives for this Baseline Assessment were therefore to assess the concentrations of contaminants of potential concern (CoPCs) and determine the potential for complete ‘source-pathway-receptor’ linkages (SPR linkages) resulting from the shooting activities undertaken on the property. Where results of the assessment indicated the presence of a complete SPR linkage, a secondary objective of this baseline assessment was to identify specific measures that may need to be undertaken to mitigate potential contamination of the Site and adjoining lands and waterways.”

The study provides a summary of two previous investigations starting with that undertaken by the club in 2013 indicating -

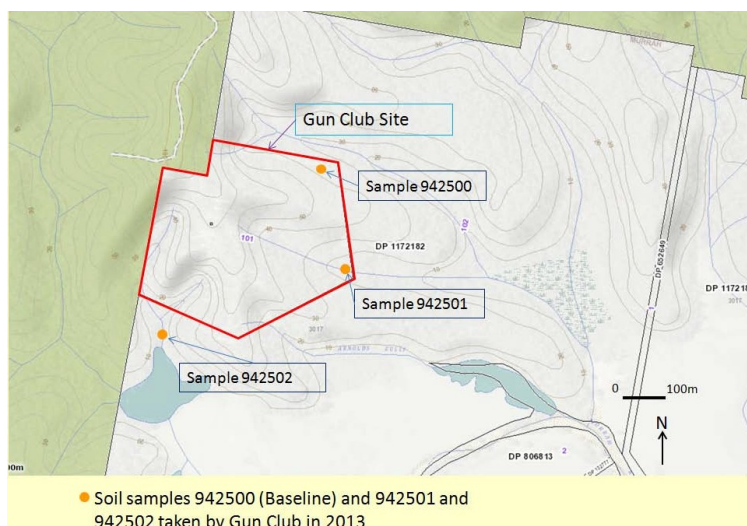
“ . . . BFG undertook sampling at four locations within the Site including the collection of samples from a control site (where no shooting had been undertaken) to establish background levels of lead in surface soils, and within two areas of the site where shooting had occurred over the past 15 years to assess the potential for elevated lead concentrations.”

- Results of the assessment indicates that soil pH was between 5.2 – 5.3 pH and that lead concentrations in soil ranged from 15 mg/kg to 30 mg/kg which was considered indicative of background concentrations.

- Laboratory analysis of a surface water sample collected from onsite drainage lines returned a concentration of 0.3 ug/L, being less than the adopted ANZECC Guidelines for protection of aquatic ecosystems in Fresh and Marine water environments (3.4 ug/L and 4.4 ug/L, respectively);

- BFG concluded that concentrations of lead were not detected above the natural variability of background lead levels and that lead (in any form) is not being significantly transported from the portions of the site utilised for shooting purposes.

The study does not provide locations or methods of the club’s samples, but refers to the MRAG investigation undertaken by Bradshaw Geoscience Consulting in 2019 (BGC, 2019). This investigation does provide the locations of the club’s samples, as indicated in the following map. Two of the club’s soil sample locations are within the current property boundary, the baseline sample being in the upper north eastern corner of the subdivision and the other in a water course.



The third soil sample location, south of the property boundary, also appears to be in a watercourse. The location of the water sample isn't provided and is problematic, for reasons to be mentioned. According to the study -

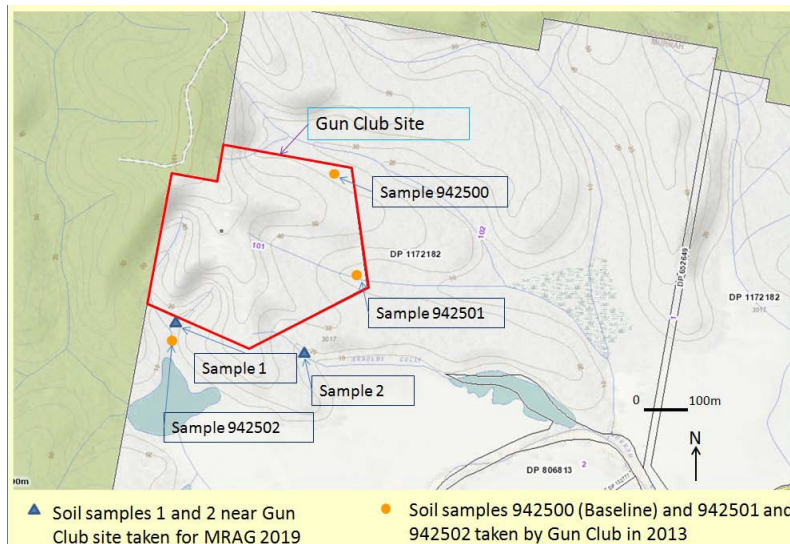
“ . . . BGC undertook an assessment of properties located adjacent to the Site to assess the potential for offsite migration of lead to be occurring. In undertaking the assessment BGC collected four soil samples in total (two targeted samples and two baseline samples).

Analytical laboratory results of the collected samples returned lead concentrations of 97 and 162 ppm within targeted samples and 21 and 22 ppm within collected baseline samples. Based on the results of the investigation, BCG concluded that lead contamination is not being contained to the boundaries of the Site as lead concentrations are elevated on the property adjacent to the Site and that lead concentrations were therefore, in BCG's view, observed to have increased since the 2013 study.

In undertaking a review of the BCG assessment ERM notes the following:

- The sample collection methodology and sample density were not in accordance with regulatory guideline criteria (ASC NEPM and /or the NSW EPA requirements for reporting on contaminated sites).
- Collected samples were submitted to ALS Geochemistry laboratory instead of ALS Environmental laboratory. ERM notes that ALS Geochemistry are not NATA accredited for the required analysis.
- Results from collected samples were compared to ANZECC 1999 guidelines which are applicable to water, not soil.
- The conclusions relating to the distribution of lead in soils both on and offsite were based on a limited dataset.”

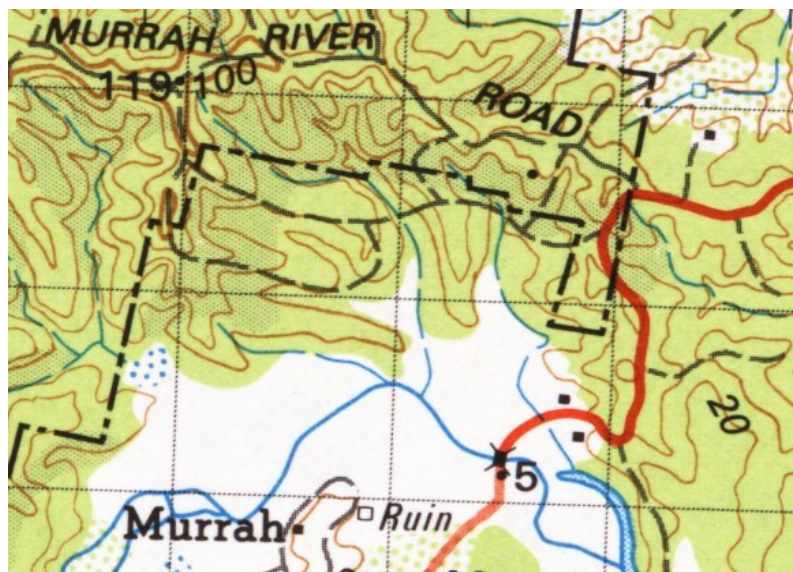
The following map from the BCG assessment shows its two soil sample sites and the locations of the club's three sites.



It is apparent that the three sample locations outside the property boundary are in the area used for shooting in the 15 years prior to the subdivision. However, the BCG assessment did employ the correct method of sampling and used the same laboratory as the club. BCG took 2 samples from private property in the adjacent Brockeloes creek catchment for its baseline samples.

The study references the requirements for contamination consultants (EPA, 2020) that includes ‘past and present potentially contaminating activities (on- and off-site sources)’. The map below shows the property in 1982. The two roads passing through the area aren't indicated on current maps, however roading generally remains evident for several decades and trees rarely grow back on the

compacted surfaces. Light green dots indicate areas of medium and scattered vegetation (trees) indicating logging, which is a consistent feature of forests in the catchment.



Conceptual site model

Among concerns about the conduct study is a “Conceptual Site Model (CSM), developed by ERM, aimed at identifying ‘key sources, pathways and receptors’ of pollution. Such a model is suggested in the National Environmental Protection Council guidelines titled, “Schedule B1, Assessment of Site Contamination Measure” (NEPC, 2013). Schedule B 1 provides guidance on investigations for “Human health-based soil and groundwater criteria” and “Ecologically based soil criteria”.

The focus of the study is indicated to be “Lead and benzo-a-pyrene impact due to operation of a sporting clay club shooting range.” The source of lead being the shotgun cartridges and the benzo-a-pyrene from the clay targets. Inhalation of contaminated dust is a pathway and as indicated in the following quote -

“... Lead in the primer and the outer surface of the projectile is vaporised and released into the air at high pressures after a firearm is discharged. Shooters inhale lead particles released when a gun is fired. The particles can be absorbed from the lungs into the blood stream. Lead dust and fragments are also released when the projectile impacts solid surfaces.” (Department of Health, Environment, 2022)

The initial emission of lead occurs at the shooting stations, although the study does not identify where the stations are.

Associated with the NEPC guidelines is a ‘check list’¹ that includes gathering information from “state and local government environmental records including licensing conditions, regulatory notices, inspection records, complaints, licence breaches.” In NSW licensing conditions include the NSW Firearms Registry, as detailed in the “Range users guide’ (NSW Police, 2017).

The guide indicates NSW police licensing of shooting ranges requires the proponents to meet several conditions, aimed mostly at human safety and constraining the lead fallout area. The first of these is that “Shotgun ranges must be designed in such a manner that all pellets fall within the property controlled by the range operator.” The production of a template with the location of shooting stations and indicating the direction of shooting is also required, to identify a human ‘danger area’.

1 <https://www.nepc.gov.au/nepms/assessment-site-contamination/toolbox>

The length of this danger area ranges from 160 to 205 metres, depending on the size of the shot. The guide also indicates “Stations are to have muzzle restraints to limit the arc of fire to safe areas.”

The guidelines for shooting ranges in Victoria (Victorian EPA, 2019) indicates the arc of fire from a trap range is 100 degrees and with a fallout distance of 200 metres covers an area of 3.5 hectares on flat ground. The distance a shotgun pellet travels is further when shooting down slope and the fallout area is larger. It has been suggested the club has seven shooting stations. In the absence of evidence to indicate any overlap of the fall out areas, the total fallout area would be 24.5 hectares. The study indicates to area of the club’s property is 24.35 hectares.

The study’s Sampling Analysis and Quality Plan suggests “. . . the range of dispersion of shot from the firing position varies considerably but is generally limited to a maximum of 300 - 400 m.”, The maximum distance provides for a maximum fallout area of around 90 hectares for seven shooting stations, assuming no overlap. Seemingly in contrast the table below, adapted from the study, estimates a high impact zone and fallout area of just 3.6 hectares for seven shooting stations or about 0.5 hectares for each shooting station. The study does not provide the rational behind these areas or the associated soil sample locations.

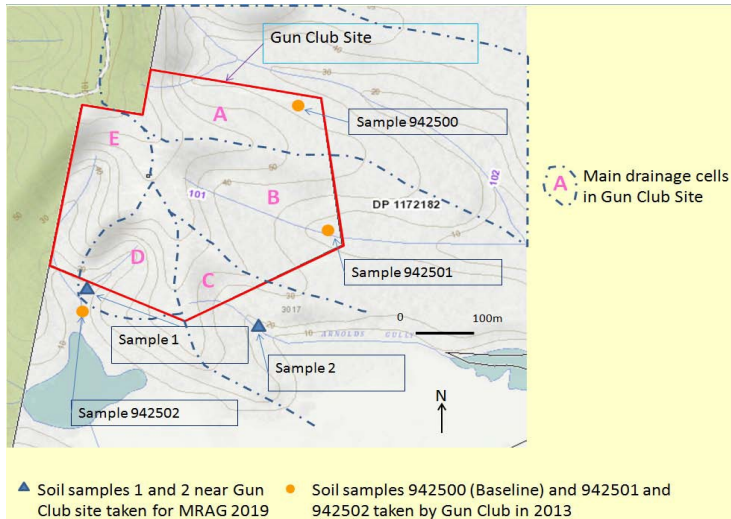
Table 1. Study impact zones

Potential impact	Area	% of property	Area (ha)
High	Impact zones/fall areas	15	3.6
Moderate	Indirect / incidental impact areas	40	9.74
Moderate	Drainage Lines and perimeter	5	1.22
Low	Outside fall zones	40	9.74
		100	24.3

The NSW Police guide also suggests “The down range area should be clear of trees and other obstacles to a depth equivalent to the flight distance of the furthestmost thrown target.” While it is apparent that shooting into trees has occurred, based on an average target flight distance of 75 metres and assuming no overlap, an area of about 0.5 ha would have to be cleared adjacent to each shooting station.

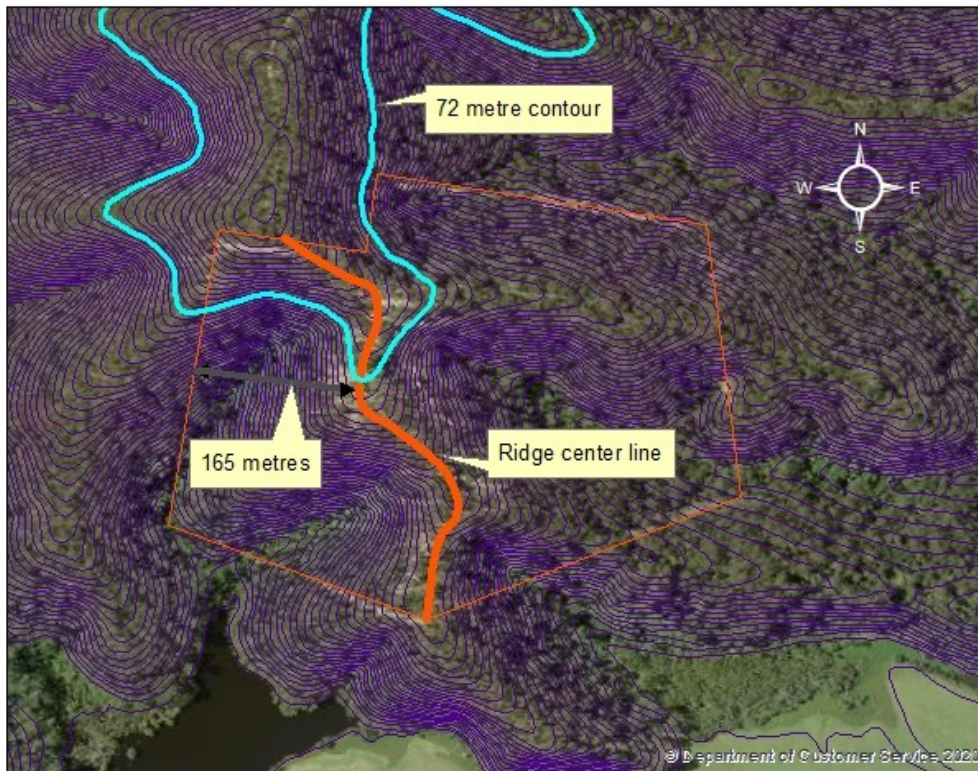
Clearing required around seven stations equates to 3.5 hectares or 14.4% of the property and would require BVSC approval. However, given the similarity of area sizes, the study’s high impact zones/fall areas may be based on NSW Police clearing requirements, rather than the probable extent of lead pollution. Areas suggested to be subject to a moderate impact include ‘Drainage Lines and perimeter’ with an area of 1.22 hectares. One of the drainage lines begins outside of the property, four begin within the property and one of these runs just outside the western property boundary for part of its length. All of these watercourses flow into the Murrumbidgee river.

Research in five unmapped or zero order streams with the same geology on the south coast and a combined length of 629 metres (Walsh et. al., 2019) found the average width of stream channels was 1.58 metres, with a maximum of 2.1 metres for a stream with a length of 187 metres.



The map above from the BCG assessment delineates areas of the five sub-catchments on the property. The total length of mapped first order streams on the property is approximately 812 metres, providing for an area of 1,705 m² with a 2.1 metre wide channel. Should the study’s area calculation for drainage lines be consistent with this area, the perimeter area would be 10,470 m². The property’s perimeter is approximately 1,960 metres in length, indicating the perimeter area, where shooting is suggested to have a moderate potential impact, occupies an area within 5.5 metres of the property boundary.

The NSW Police guide suggests permissive shooting rights may apply, among other things in the advent that ‘Projectiles may encroach on land owned by you’. The map below² shows the center of the ridge (red line) where most of the clearing is apparent and the 72 metre contour line (blue line). The distance between the intersection of these lines and the western boundary of the property is 165 metres. All of the land below the junction of the ridge line and the 72 metre contour is down-slope. If shooting is directed to the west, it most likely the lead fallout area includes the Murrah Flora reserve.



2 Imagery: NSW Department of Customer Services 2020

Contour lines on the image above are derived from Light Detection and Ranging technology (LIDAR), suggesting zero order water-courses are also present on the property.

The NSW police guide also indicates the names of all persons using shooting ranges should be recorded at each shoot. This information would provide a more detailed estimate of the volume of lead and associated pollutants. However, assuming only one target if released, a broad estimate of lead can be deduced from the following statement the club provided to BVSC.

“Competition days typically have 40 shooters where competition involves four rounds of 25 targets from six or seven shooting stations. Shooting occurs from all shooting stations once competition commences.”

Hence, 40 shooters x 4 rounds x 25 targets x 28 g of lead = 112,000 grams or 112 kilograms of lead per shoot. Further, 112 kg of lead x 12 days a year x 10 years = 13,440 kilograms or 13.44 tonnes of lead at the current site. The same calculation applied to the original site for its 15 (+) years of use equates to 20,160 kilograms or 20.16 tonnes of lead. According to the study -

“Shooting commenced in the area of the gun club in 1998 when the club formed and obtained its DA from Bega Valley Shire Council (BVSC) in 1999, allowing it to shoot on 12 days each year. This shooting was mostly along a ridge on the southern boundary of the club's land and outside the present property boundary. The club purchased its land in 2012 and has since directed its shooting activities so that lead shot does not enter adjacent land. No shooting has been undertaken within the property boundary adjacent to the north-eastern and eastern boundaries.”

The location of the club's sediment traps, gained under the GIPA Act, (Attachment 3), infers the current shooting area overlaps with the original shooting area, hence areas at the southern end of the current area would have lead deposition over the 24 years of shooting. Areas to the south would have lead deposition for the initial 15(+) years of the club's operation and the area in the north of the current subdivision for the past decade.

The Bega Valley Shire Council is the determining authority for development applications, including the activities at the clay target shooting range. According to the National Parks and Wildlife Service (NPWS), Director South Coast Branch, (email from K.Weeks. 19 November 2021), the NPWS provides advice and information to Council if the development application may potentially impact a national park. However, the NPWS manages the Murrah flora reserves and did provide advice to BVSC supporting the doubling of shooting days (Attachment 3).

Soil sampling

“. . . In general, when the source of contamination is known or is suspected to be limited to a specific area, sampling points are located relative to the suspected source(s) using judgemental sampling stepping out from the suspected source location, or systematic grid sampling centred on that location.” (NEPC -Scheule B2, 2013)

An alternative to the study's soil sample locations could have been the NSW Environment Protection Authority's "Contaminated sites sampling design guidelines" (EPA, 1995), These guidelines specify an unbiased approach based on systematic grid sampling and appropriate statistical analysis. Similarly sampling locations could have been along transects, based on the locations of shooting stations (NPEC, 2013). Had the survey methods employed in the study been based on the guidelines, concerns about potential bias may not have been raised.

Another concern with the study is the appropriateness of soil sample methods, indicated as being at a depth of 0.1-0.2 metres. While the study suggests, “The sampling strategy (including depths and

locations) was considered appropriate for the purpose of the investigation.” In contrast, the BGC assessment employed surface samples. This latter approach to soil sampling at shooting ranges is consistent with the most recent advice from the NSW EPA³ advising -

“ . . . The sampling depth and interval is dependent on the CSM, DQOs and mode of contamination. NEPC 2013, B2 states that ‘at the surface, samples at 0–100 mm or 0–150 mm should be taken unless there is evidence of a thin surficial layer of contamination’. Examples of such situations include rifle ranges and broadacre agricultural sites.”

Concerns were also raised about the apparent lack of “robust sampling off-site for contamination” such that natural background levels of pollutants could be established. The “Assessment of Site Contamination Measure” (NEPC, 2013) indicates -

“ . . . Derivation considers the physicochemical properties of soil and contaminants and the capacity of the soil to accommodate increases in contaminant levels above natural background while maintaining ecosystem protection for identified land uses.”

and

“ . . . In natural soils there are wide ranges of concentrations for certain elements, such as chromium, manganese, nickel and vanadium. These concentrations depend on the origins of the soil. The EILs may be exceeded in certain regions and it would be more appropriate to apply regional background levels for comparison in assessment of site contamination. If such data are not already available, samples from adjacent property (not suspected of being contaminated by the activity which led to the site investigation being instigated) should be analysed to establish regional background levels.

The study initially proposed five background sample locations, four of which were along the northern boundary of the current subdivision. The locations are close to the study’s soil sample sites SS01, SS03, SS33 and SS34. These sites are indicated as having 14, <5, 20 and 9.8 mg/kg of lead respectively from samples taken at 10-20 centimetres. Lead at sites SS03 and SS34 were the lowest concentrations found in samples from the club land.

The other background sample location (SS53) was upstream on the Murrumbidgee river where the lead content is indicated as 10mg/kg.

Data outliers

“ . . . All data resulting from probability-based sampling must be included in the subsequent inferential statistical analysis, unless: • it can be demonstrated with a high level of confidence that the individual data points are invalid due to transcription errors, data coding errors, or measurement errors in the laboratory analysis or • the individual data points are subsequently identified – again, with a high level of confidence – as part of a hotspot, and the hotspot is appropriately remediated or managed and thereby effectively removed from the population. In either case, a determination is then needed as to whether further data needs to be generated through additional investigations, or if sufficient data is available to support the required decisions. These determinations should include appropriate statistical analysis of the remaining dataset. (EPA, 2022)

While the lowest lead concentration <5mg/kg at site SS03, was apparently not included in the statistical analysis. The highest reported lead concentration in the study was at SS43, from a sample taken on 27/5/20, where a concentration of 1000mg/kg of lead was found at a sample depth of 10 to 20 centimetres. The study also indicates a sample taken at SS43 at a depth of 20 centimetres, on the day before the first, identified 60 µg/L, while the laboratory data indicates or 60 mg/L of lead.

3 https://yoursay.epa.nsw.gov.au/download_file/878/473

The highest benzo-a-pyrene concentration of 1.1mg/kg was reported from a bore hole sample BH03 at a depth of 20 centimetres. The study also indicates “. . . field screening with a calibrated PID returned concentrations ranging from 0.2 ppm – 3.7ppm (SS12 and SS13) which are not considered to be indicative of anthropogenic contamination.” All of these outlier sites are within the southern portion of the current site where shooting has been undertaken since 1997.

Water and sediment sampling

The study’s preliminary conceptual model proposed 19 water and sediment sample locations due to the ‘high risk’ of negatively impacting ‘off-site human and ecological sensitive receptors’. Seven of the initial water sample locations were planned within the boundary of the clubs land. Surface water flows in these sub-catchments generally only occurs after > 75 mm of rainfall and only for a few days post rainfall (Walsh et al, 2019). Hence, most of the water sample sites were changed to soil sample locations, due to the dry weather and lack of water. Similarly dry weather prevailed at the time of the club’s water sample.

The refined conceptual model provided for six water and sediment sample locations, none of which are on the property. Two of the water sample sites were in Arnolds gully, the closest body of water to the club, at the end of sub-catchment C (BGC, 2019). The other four were on the Murrah river with three upstream and one down stream of Arnolds gully. The study suggests a total of eight water samples were taken over the three days of field work. Four of these are indicated as being undertaken on the first field survey day, the 26th of May (SW01, SW02, SW03 & SW04), two were the next day (SW02 & SW03) and two the following day (SW05&SW06). However, the ‘Daily Environmental Report’ sheets in the study indicate six water samples were taken on the third and last day of field work.

The study reported levels of antimony of <5µg/L in six out six water samples. The Australian drinking water standard for antimony 3 µg/L. Lead was reported as exceeding the standard for the protection of fresh water in three of six samples and exceeding the standard for the protection of marine water in one of the samples.

Two of the six water samples were reported to have an electrical conductivity (EC) suitable for drinking water, one was above the recommended level for human consumption, but suitable for some stock and three sites were recorded with EC readings rendering the water’s suitability to flushing toilets. Two of the six samples were reported as having a pH below both the standards for the protection of fresh water and the protection of marine water.

All of the sediment samples in the Murrah river were found to have lead level <5 mg/kg, which is consistent with the low capacity of pollutants to attach to coarse river sand. Samples in Arnolds gully returned concentrations of 10mg/kg and 22mg/kg at the western end of the gully closest to shooting areas. Only two of the sediment samples (SW2 & SW3) were tested for Benzo-pyrene, both of these sites were in the Murrah river above the junction with Arnolds gully.

The study also indicated that “. . . *During surface water and sediment sampling within the Murrah River approximately 0.2 m of water was present at sample locations with the water clarity being noted as clear; During surface water and sediment sampling within Arnolds Gully it was observed that there was approximately 0.5 – 1 m of water at the sample locations with the water being noted as turbid.*”

EPA response

In response to community concerns about the study the NSW Environment Protection Authority (Attachment 1), focused on the results rather than the conduct of the study and suggested -

1. *Antimony was not found at detectable levels in any of the sediment samples, soil samples or surface water samples collected in and around the Murrumbidgee River.*

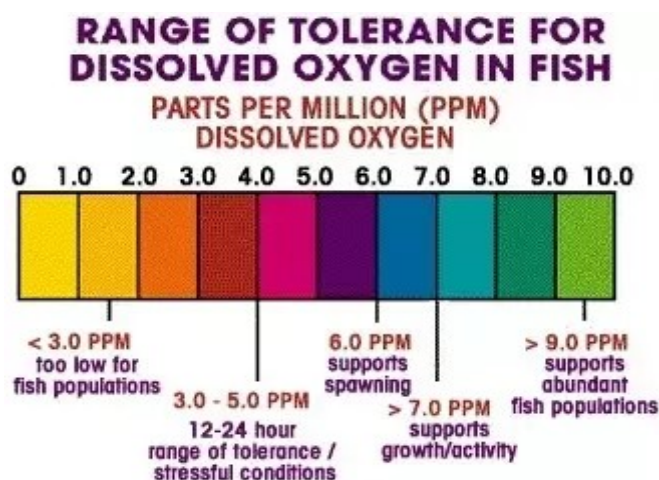
In addition to the survey methods, the capacity to accurately measure pollutants in soil, sediment or water is constrained by the Limit of Reporting (LOR), that is ‘*the minimum concentration of a substance in a sample that can be reliably detected by a laboratory.*’ The following table compares the LOR for metals in the study with those employed by the National Measurement Institute (NMI).

	ERM LOR	NMI LOR
Antimony	.005 mg/L	1 µg/L
Arsenic	.001 mg/L	-
Lead	.001 mg/L	1µg/L

One milligram per litre (mg/L) is the equivalent of 1,000 µg/L. The study’s laboratory analysis for Antimony has an LOR that is 5 times greater than the NMI LOR, and is apparently unable to detect concentrations below 0.005 mg/L. Despite this limitation the study suggests an average antimony concentration of 2.5 µg/L for all samples.

2 *All surface water lead results in and around the Murrumbidgee River were below ANZG 95% Protection Values for marine waters and fresh waters (3.4 µg/L and 4.4 µg/L respectively). Additionally, the EPA notes that the surface water sample collected upstream of the site, ‘SW01’, had the highest lead level of 3 µg/L.*

As the study’s laboratory analysis was based on milligrams per litre, it is possible that measuring fractions of a milligram could be below the laboratory's LOR. However, the study’s upstream control sample ‘SW01’ with a lead concentration of 3 µg/L, suggests a different upstream source of lead. Surface water sampling at site ‘SW01’ also identified a Dissolved Oxygen level of 0.78 parts per million. As indicated in the following online guide, this concentration is too low to support fish.



3. *All surface water lead results are significantly lower than the water quality trigger values for livestock drinking water of 100 µg/L (ANZG, 2018).*

While lead in the water may not be a concern for livestock, water with elevated levels of electrical conductivity would be unlikely livestock drinking water. However, it is likely that shooting in the original location did result in fallout on the river flats, where beef cattle graze.

4. *Sediment samples collected in an around the Murrah River had lead results that are significantly lower than the 'Recommended default guideline values for toxicants in sediment' for Lead – 50 mg/kg (ANZG, 2018).*

There are thousands of tonnes of sediment in the Murrah river and it is largely composed of coarse river sand and small stones that move constantly and more so during periods of elevated flow. Under the heading “Refining guideline values for local conditions” it is suggested

“ . . . Bioavailability and toxicity of contaminants is influenced by sediment grain size. The contaminant binding capacity of sediments decreases with increasing grain size, and this results in the concentration of contaminants typically being greater in the finer sediment fractions. The data used in the effects database were largely associated with silty rather than sandy sediments so the DGVs are most applicable to silty sediments.” (ANZG, 2018)⁴

As a particle size analysis of the sediment appears not to have been undertaken, only two of the sediment samples may have been suitable for analysis. The study does not refer to the BVSC approved sediment traps (Attachment 3), although soil sample sites SS23 and SS40 are close to them. Shotgun pellets are a little over 2.2mm in diameter, the sediment traps would require very fine mesh to collect any pellets landing in and being moved down the watercourses. It seems unlikely mesh of this size would survive even a small flow in the watercourses, given the leaves and sticks flowing water would bring with it.

5. *Soil samples collected around the Murrah River had significantly lower lead results than the investigation levels for 'National park and areas with high ecological value' - 470mg/kg - outlined in Table 1B(4) of the National Environment Protection (Assessment of Site Contamination) Measure April 2011 Schedule B1 – Guideline on Investigation Levels for Soil and Groundwater (NEPM, 2011).*

The selection of soil sample sites and the sampling method for the study was not undertaken in a manner consistent with the requirements for determining contamination at shooting ranges. It is arguable that the 1,000 mg/kg reported at sampling site SS43, should have alerted the EPA to uncertainty regarding the selection of survey sites. The NPWS has not responded to community requests to undertake soil sampling in the Murrah Flora Reserve, adjacent to the shotgun club.

Consequently, Friends of the Five Forests offered to fund some limited water analysis and further water sampling was undertaken with a focus on antimony, lead and water EC.

The Dry/Murrah river catchment

The Dry/Murrah catchment occupies an area of around 19,500 hectares of which about 6,450 hectares (33%) is cleared, mostly in the upper Dry river catchment (Scott,1999). A study of the Narira creek catchment (Brierley and Murn1997), adjacent to the Dry river catchment found -

“ . . .Upland valley fills in Cobargo catchment, on the south coast of New South Wales, represent substantial sediment source zones. Contemporary channels within these fills are up to 8 m deep and 50 m wide for catchment areas < 10 km². Virtually all banks are eroding. Downstream of this sediment source zone, sediment transfer zones are characterised by sinuous channels that are partially choked by sands released from upland valley fills. Coarse sands stored in point bars deflect

4 <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants>

flow to outer banks where colluvial footslopes are eroded. Approximately 50% of banks are eroding in this section of the catchment. Other than the 10 km river reach upstream of the river mouth, the remainder of the catchment is a bedrock-confined sediment throughput zone, characterised by fluctuations in channel bed elevation. The downstream 10 km of the catchment is a sediment accumulation zone, in which erosion is restricted to occasional concave banks. Prior to European settlement of Cobargo catchment, upland valley fills were largely unincised, and middle (transfer) reaches of the catchment comprised swamps. Vegetation clearance, along with disturbance and drainage of swamps, transformed discontinuous water courses into continuous channels. Working from a base-point of intact upland valley fills, almost 50% of available material has been removed from the upper catchment sediment source zone, contributing 2.9×10^6 m³ of material to the lower catchment. Of this, roughly 65% has been stored along the channel bed and floodplain. This gives a total sediment contribution to the delta of 1.0×10^6 m³. Sufficient materials are stored in transient storage units along transfer zones to maintain current rates of sediment throughput to the delta for several decades. Cobargo catchment experienced dramatic acceleration of channel incision and bank erosion processes within a few decades following European settlement of the catchment (i.e., around 1830). Transition in landscape form and associated sediment delivery were rapid, with a negligible lag interval (i.e., within a few decades of disturbance). However, given the extensive volume of sediment released from upland valley fills, landscape recovery (i.e., refilling of upland valleys) will likely take thousands of years.” (Brierley & Murn, 1997)

The majority of the cleared areas in the Dry river catchment have the same geology, Cobargo granite, and similar outcomes from clearing for agriculture. Cobargo granite is one of 130 separate plutons associated with the Bega batholith, that increase with age from east to west (Stirling et al. 2022).

However, unlike the Cobargo catchment, the majority of sediment deposited on the Murrah river flood plain is a result of deposition since the 1960's with some 30% the result of the 1971 flood (Wallbrink et al. 1999). Hence, it may not be appropriate to compare soil production and erosion rates of granitic geologies (Dossato et al. 2008) with sedimentary geologies (Walsh et al. 2020).

To the east of the Dry river catchment is Mumbulla mountain an anhydrous granite intrusion from the Upper Devonian period (Tulau 1997). Further to the east the dominant geology is Ordovician sediments and meta-sediments, the oldest geology in the catchment and forming the erosional Murrah soil landscape (ibid).

As the name suggests meta-sediments have hundreds of different layers that have rocks of variable hardness, some of which have evolved into clays and in many instances have been moved over time such that the layers may be vertical. Murrah soil landscape soils have several limitations including, soils of low to very fertility, sodicity and dispersion (ibid). The Murrah- Mumbulla residents engaged a soil chemist who took 84 soil samples from depths up to 160cm at several locations on State Forests and private land in the Murrah river catchment. Laboratory and multiple regression analysis found soils in all auger samples were dispersible and increasingly so at increasing depth due to a low proportion of Calcium in the soils, relative to Sodium (Little,1994). As clays breakdown they produce colloidal materials including aluminium that is toxic to most vegetation.

This information was provided to the NSW EPA prior to its move from an Environment Pollution License for forestry operations to an Environment Protection License in 1996. While the EPA did incorporate soil dispersion of top soils into the new license, it rejected the finding that sub-soils are significantly more dispersible. The EPA has not modified its position since that time and forestry operations have continued without consideration of the negative impacts on soils to the depth from which tree roots take most of their water.

Areas of land degradation in the Bega Valley shire were identified in surveys undertaken between 1985 and 1992 (NSW Department of Lands, 1992) as indicated in the following table. No other land degradation surveys have been undertaken since that time.

	Type	Area (ha)
Mass movement	Slide	20
	rock debris avalanche	6
	Slump	3
	soil debris avalanche	11
Rill erosion	extreme rill erosion	28
	severe rill erosion	40
	moderate rill erosion	67
	minor rill erosion	182
Sheet erosion	extreme sheet erosion	940
	severe sheet erosion	988
	moderate sheet erosion	2215
	minor sheet erosion	6798
Wind Erosion	extreme wind erosion	21
	moderate wind erosion	1
	minor wind erosion	14

One of the visible signs of sub-soil dispersion is mass movement or ‘slumping’ of the surface soil. The following quote suggests such areas are becoming more common in south coast forests on the same geology as the Murrah soil landscape.

“ . . . Localised mass movement forming hollows around the heads of 1st order streams are not uncommon in this terrain. HC should pay extra attention around these areas when locating extraction tracks.” (Forestry Corporation, 2022)⁵

Forests

“ . . . Trees and shrubs have roots that can penetrate deep into the soil and, as a consequence, are able to extract water throughout much of the soil body. On the other hand, grasses, grasslike plants, and forbs have relatively shallow root systems and are only able to use water in the upper foot or so of the soil mantle.” (De Bano et al. 2008)

All accessible areas of forest east of Mumbulla mountain were subject to logging and sleeper cutting prior to the introduction of integrated logging in the 1970’s. Clear felling, referred to as ‘Timber Stand Improvement’ (TSI) was also undertaken across around 1,200 hectares, with the aim of providing sawlogs, after the first cycle of integrated logging. The theory behind TSI and integrated logging was and remains that removing most of the trees would allow more light in and encourage the growth of eucalyptus species.

The negative impacts of logging are well documented as indicated in the following quote from a logging study on the north coast of NSW -

“ . . . The extraction of biomass in addition to sawlogs and other high value log products may have implications for the future nutritional needs of the forest. When a forest is harvested, nutrients may be lost in harvested wood, bark and other tree components, and there are further losses by volatilization and particulate convection during regeneration burning, and by erosion and leaching⁶. The impacts will be different for native systems compared to plantations. Because of shorter rotation

⁵ <https://bertramr.files.wordpress.com/2022/03/dampier-state-forest-compartment-3231a-harvesting-roading-plan-public-version-1.pdf>

times, harvest of timber is more likely to lead to a decline in productivity in plantations than in native forests, despite the application of fertilisers 2. The higher intensity of the harvest (i.e. clearfell), and also previous land use impact on nutrient levels for plantations.” (Department of Primary Industries - NSW. 2017)

This study found eucalyptus leaves contained a greater mean concentration of major nutrients, Nitrogen, Phosphorus, Potassium, Magnesium and Sulphur. Calcium concentrations were generally greater in bark than leaves at three locations, but was slightly higher in leaves at one location.

Historically, Bega dry grass forest (Keith & Bedward, 1999) dominated by forest red gum (*E tereticornis*) in the upper catchment supported koalas at a higher density. Two main forest ecosystems, Coastal foothills dry shrub forest and Coastal gully shrub forest dominated the Murrah soil landscape, with occasional areas of Warm temperate rain forest in moister gullies (ibid).

A study on leaf chemistry of trees in the latter ecosystems (Stalenberg, 2010) found little difference in the available nutrient content in leaves from trees of the sub genus *Symphomyrtles* and *Monocalypts*. The former sub genus includes the historically preferred forest red gum and those most preferred by koalas on the Murrah soil landscape, including woollybutt (*E. longifolia*) and monkey gum (*E. cypellocarpa*). *Monocalypts* include silver-top ash (*E. sieberi*) and blue-leaved stringybark (*E. agglomerata*), that are less preferred and silver-top ash had the lowest available nutrients. According to the study -

“ . . . Six of the eight tree species visited by koalas at Bermagui-Mumbulla had similar concentrations of available nutrients and toxins to primary feed species preferred by koalas in Victoria and other areas including manna gum (*E. viminalis*), Tasmanian blue gum (*E. globulus*) and Sydney blue gum (*E. saligna*). This suggests that the tree species at Bermagui-Mumbulla have similar nutritional quality to well-known koala favourites which gives us hope that the area has potential to support higher density populations than previously thought.

The mystery remains: why are koalas at such low numbers in the Bermagui-Mumbulla forests? The answer potentially lies with the impacts from historical and ongoing disturbances from land clearing and fragmentation, forestry activities and fire. Additionally, the region has experienced prolonged drought which can suppress leaf flushing, decrease leaf water content and lead to tree die back; thereby reducing the availability of higher quality foliage.” (Stalenberg, 2010)

Based on data from the NSW government koala surveys, the main eucalyptus species germinating after integrated logging and the subsequent post logging burn, in these previously mixed species forests, is silver-top ash (*E. sieberi*.) (Adamack et al. 2016). Further research found -

“ . . . Simulations of forests with increasing proportions of *E. sieberi* showed that AvailN decreased from 1.1% when *E. sieberi* was $\leq 10\%$ of all eucalypts to 0.7% AvailN when *E. sieberi* was the only species present. Consequently, forests dominated by *E. sieberi* are unlikely to support koala populations based on existing knowledge of koala nutritional requirements. Foliage nutritional quality is a critical but often overlooked element of habitat quality for leaf eating animals, and this study demonstrates how disturbance related changes in tree species composition can impact the nutritional landscape and the occurrence of folivores.” (Au et al. 2019)

On less fertile sites silver-top ash regeneration is poorer and non-eucalyptus and black forest oak (*Allocasuarina littoralis*) and occasionally various wattle species tend to dominate. Frequently Black forest oak may be the only species that grow back after integrated logging. The analysis of data from NSW government koala surveys between 2010 and 2013 (Adamack et al. 2016), found Black forest oak was the second most numerous species and most numerous non-eucalyptus species. However, this result is probably due to the decision to increase the size of trees measured, from 100 to 150mm Diameter at Breast Height, soon after the government koala surveys began. The

abundance of this species was first reported in the year 2000 as part of the forest inventory for the Southern Regional Forest Agreement, where every tree in a 50x 50 metre plot, in what is now Kooraban National Park, was a black forest oak.

Wattles and black forest oak fix atmospheric nitrogen in soils and should be understood as successional or seral species, that provide soil conditions more suitable for eucalyptus germination and growth. This understanding is necessary if the intention of management is to increase soil fertility and encourage the germination, growth and maturity of trees suitable for arboreal species and the development of trees large enough to develop suitable hollows, on which many species depend.

The level of soil fertility required to grow large trees and maintain forest health is sustained through the interactions between flora and fauna (Department of Agriculture and Water Resources.1992). Most if not all animals die in coupes subject to integrated logging. While claims the 40 year rotation disperses the impacts of logging through space and time, the majority of integrated logging in the Murrah catchment occurred over a period of <20 years.

Fauna that are essential for maintaining soil fertility include bandicoots and potoroos. The former through their digging that incorporates organic matter into soils and potoroos that also consume the fruiting bodies of fungi (truffles) and spread their spores through the forest.

A requirement under the Eden Regional Forest Agreement, that was intended to be legally binding, was for Forestry corporation to undertake an inventory of production forests. The purpose was to establish a baseline in regrowth forests and ongoing data collection on the recruitment, growth and mortality of trees. Forestry corporation did not comply with this requirement.

Much like clearing, integrated logging radically changes both surface and sub-soil hydrology, greatly increasing both surface soil erosion and sub-soil dispersion. In addition to the immediate post logging reduction of surface soil fertility, the dispersion of sub-soils reduces soil Water Holding Capacity (WHC). This outcome is associated with the reduction ecological process resulting from to the loss of native species, due initially to feral predators, that previously maintained soil fertility and forest health, followed by intensive logging, the post logging burn and prescribed burning.

The first indication of a reduced WHC was during a short dry spell in 1998 when extensive areas of forest on the south coast turned brown (Bertram 2019). A subsequent declared drought between 2002 and 2004 led the acknowledgement that eucalyptus die-back associated with dry weather and official drought (DADD), when forest canopies on ridges and slopes turn brown, is a major threat to koalas (NSW Scientific committee. 2007). More recent research has confirmed that ‘hydraulic failure is strongly associated with canopy die-back during drought in eucalypt forests’ (Nolan et al. 2021).

Bell-miner associated dieback (BMAD) is listed as a key threatening process in NSW and is generally found in areas in gullies and along streams on the south coast. Associated with BMAD and more wide spread is ‘viney scrub’. There has been a significant increase in areas of viney scrub over the past thirty years.

“ . . . Some of the moist gullies are dominated with vine which is encroaching up the ridges and will most likely inhibit regeneration after harvest if left untreated. The FT/HC must identify such areas and ensure that adequate seed trees are retained in these areas (and target trees containing vine for

removal). Utilise harvesting machinery to disturb the soil, to create a seedbed for regeneration and inhibit further vine spread.”(Forestry Corporation. 2015)⁶

There appears to be no research confirming soil disturbance will inhibit the spread of vines, however the evidence does suggest small trees are readily killed when vines grow over them. The approach being taken by Forestry does not consider the changes to forest hydrology or soil physical and chemical conditions that come from logging upslope.

Following a nomination to list DADD with BMAD (Bertram 2019), the NSW Threatened Species Scientific committee made an unpublished decision⁷ that DADD is a result of all listed key threatening processes, including BMAD. There has been very little progress toward an understanding of the processes behind forest dieback over the past 30 years (Attachment 4).

Fire

Traditional management

“... **Nitrogen Losses**—An Enigma— It has been conclusively established by numerous studies that total N is decreased as a result of combustion (DeBano and others 1998). The amount of N lost is generally proportional to the amount of organic matter combusted during the fire. The temperatures at which N is lost are discussed above. In contrast, available N is usually increased as a result of fire, particularly NH₄-N (Christensen 1973, DeBano and others 1979, Carballas and others 1993). This increased N availability enhances postfire plant growth, and gives the impression that more total N is present after fire. This increase in fertility, however, is misleading and can be short-lived. Any temporary increase in available N following fire is usually quickly utilized by plants within the first few years after burning.”(De Bano et al. 2008)

The traditional owners used fire for many purposes, burning grass lands for hunting was one use as it provided a temporary boost in Nitrogen availability for grasses, in forest ecosystems with a grassy under-storey and where running to spear animals was possible. However, various roots and tubers were dug up, usually by women and were frequently a staple of the diet (Gott. 2005). This action mimicked that of animals largely responsible the bioturbation required to maintain soil fertility.

On the south coast, accounts of Aboriginal management have been described as ‘conjectural’ due to the paucity evidence and unbalanced accounts -

“All early observers of Aborigines were males, who reported on the highly visible, prestigious male-dominated activities such as hunting and male initiation ceremonies. The less flamboyant but none the less vital activities of Aboriginal women, such as collecting bush foods, went largely unnoticed.” (Feary, 1988)

It is generally accepted that the coastline was a significant food source as demonstrated by the frequent middens along the coast. More nutritious shellfish like abalone were probably gathered on rocks and in shallow water. The current use of modern diving equipment enables the taking of abalone much further from the shore and in much deeper water. Fire was used on many of the coastal headlands to keep them free of trees. However, archaeological surveys in the Five Forests found -

“... Away from the immediate coastline, all sites were surface scatters of stone artefacts and most were located along ridge lines. This pattern of site distribution suggests that the sites may represent 'transit camps' of people moving through the forest making use of ridge lines as natural corridors, rather than foci of occupation for groups living close to forest resources.” (Byrne, 1983a)

6 <https://bertramr.files.wordpress.com/2022/11/bodalla-3027-harvest-plan.pdf>

7 <https://bertramr.files.wordpress.com/2019/09/ktp-dadd-nsw-tssc-response-september-2019.pdf>

Despite the lack of evidence the traditional owners ever burnt these forests or the fact that burning reduces soil fertility, so called cultural burning is now employed in addition to broad acre hazard reduction burning.

“ . . . There are potentially significant co-benefits for the Reserves and the local community, particularly Aboriginal youth, if administrative hurdles to cultural burning operations can be overcome. Some of these initial challenges have been addressed, with cultural burning now incorporated into a draft landscape wide fire management plan. cultural burning now incorporated into a draft landscape wide fire management plan.” (Natural Resources Commission, 2021)

Proponents of the cultural burning program⁸ have suggested it will help koalas by increasing water infiltration into soils and provide the nutrients for trees to grow. Removing ground cover increases erosion and even low intensity burning reduces available nutrients.

The following photo shows the outcome from one of the cultural burns, undertaken in Mumbulla state forest during 2022. The tree was scorched for several metres up its trunk, some surrounding trees were killed in the burn and others have died since that time.



An adjacent area, that was burnt the year before was burned again in 2022. After the first burn dozens of wattles sprouted in one location, although there wasn't enough litter to support a second fire and most of the wattles appear to have been removed by hand, during the second burn. In adjacent areas that did burn again the fire extended into an incised zero order watercourse.

These burns were about one hectare each, however the most recent burns have been enlarged to 20+ hectares.

8 <https://www.abc.net.au/news/2022-04-17/koalas-saved-by-traditional-indigenous-burning/100988672>

Unplanned fires

“. . . The most basic soil chemical property affected by soil heating during fires is organic matter. Organic matter not only plays a key role in the chemistry of the soil, but it also affects the physical properties (see chapter 2) and the biological properties (see chapter 4) of soils as well. Soil organic matter plays a key role in nutrient cycling, cation exchange, and water retention in soils. When organic matter is combusted, the stored nutrients are either volatilized or are changed into highly available forms that can be taken up readily by microbial organisms and vegetation. Those available nutrients not immobilized are easily lost by leaching or surface runoff and erosion.” (De Bano et al. 2008)

Unlike post logging burns, there are maps of unplanned burns and planned burns (Biamanga National Park Management Board. 2011). The largest unplanned fire was in Mumbulla State Forest in late 1980. This fire is tagged as being started by lightning (Map 3), although forestry reports suggest the source was 'possible escape from bark heap but may have been deliberate arson.' (Lunny & Moon 1988). At the time bark from logged trees was pushed into heaps, that could smoulder for up to 18 months. Another fire in Murrumbidgee state forest and a fire south of Eden on the same day are also associated with post-logging burning of bark dumps. Subsequently bark was required to be spread in the logged area (Bridges, 1983).

Although the 1980 fire in Mumbulla (Map 4) is indicated as initially heading in a south-east direction (Lunny & Moon 1988), it spread in all directions.

The Badja fire

The Badja Forest Rd – Countegany fire is understood to have started from a lightning strike in logged production forest on the eastern edge of the tablelands. Soon after the ignition was the only opportunity to control the fire and this could only be achieved with aircraft. After spreading into Wadbilliga National Park it developed into a fire storm driven by 'Foehn winds' (Sharples et al. 2010).

Wadbilliga National Park contains mostly non-commercial forests where small trees grow on soils that are shallow, stony and have very low fertility. The area is generally very steep and inaccessible and part from an increase in mostly planned fire frequency, there has been little change to these forests over the past two hundred years. There is no evidence to support claims that the traditional owners ever burnt them.

However, the traditional owners are known to have undertaken burning during winter, in the grassy forest ecosystems that were cleared for agriculture, on the eastern edge of Wadbilliga. Despite this it seems likely the outcome in terms of what burned on New years eve 2019 would have been similar.

Soon after reaching Cobargo, the winds supporting the storm greatly reduced and residents at Coolagolite, where the fire did not reach, reported rain. To the north the fire burnt Kooraban NP and to the south it lit up the western and northern edge of Biamanga NP that were intensively burnt (Map 6). However the fire's initial momentum had essentially been trapped behind Mumbulla mountain. At Quaama residents spoke of the intense heat and wind blowing from the south bringing the initial flames and then a second burst of flames from the north west.

In the coming week the fire made three 'runs' one from Kooraban NP to Bermagui SF, another from Biamanga NP into the flora reserves along the north eastern edge of Cuttagee catchment and the third across the top of Mumbulla mountain where it entered the western edge Mumbulla State Forest. These areas would seem to define the extent of north westerly winds during the fire. From

the start and through the weeks the fire continued to burn there was little or no wind in and south of the Murrumbidgee River, apart from an occasional gentle north easterly breeze.

Currently the only method to stop forest fires under mild conditions is the construction of control lines along roads and back-burning. However, physical thinning, within 10 metres of roads would enable a quicker response and provide the opportunity for a sustainable local industry based on the woody biomass that is currently bulldozed into heaps during control line construction and road grading. The same applies to woody biomass consumed in 'pile burns' undertaken on private land.

While heavy machinery may be required for some aspects of forest management, it would not be required for physical thinning and is undesirable when the negative impacts on soils is considered.

There may even be scope for a proportion of the biomass to be used in conjunction with slow pyrolysis technology to produce bio-char, to increase soil fertility. Such an approach would also greatly reduce the significant volume of CO₂ released into the atmosphere from broad acre burning. The reintroduction of species required to maintain and increase soil fertility and reduce ground fuel, coupled with an appropriate feral predator control program would be a priority, if the intention of management was to restore forests and keep koalas alive in the wild.

Planned fires - Hazard reduction burning

A significant factor resulting from all fires is the increased activity of cats and foxes (Doherty et al. 2023). There appears to be no consideration of the negative impacts feral predators have on native species from planned fires.

Research into the effectiveness of prescribed burning found it does not provide 'leverage' over unplanned fire in the South-east Corner Bioregion (Price et al. 2015). The research recommends fuel reduction should be focused on locations immediately adjacent to assets, which along with other preparations for fire is what many landholders do.

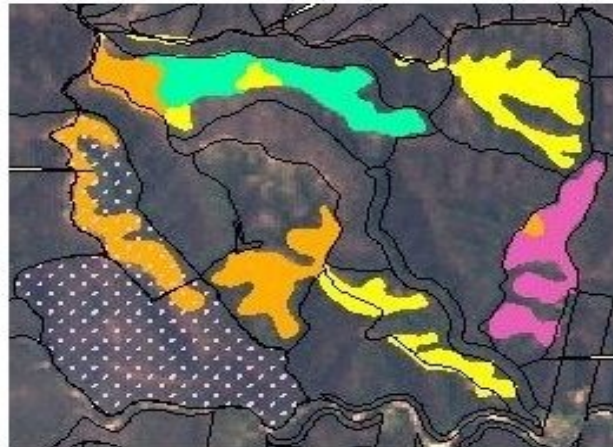
Similarly, the NSW bushfire inquiry undertaken after the 2019-2020 fires suggests - "... A suite of targeted and more strategic hazard reduction activities across all tenures working from the perimeters of settlements outwards and involving communities in their design and implementation, should be a feature of future fire management planning and preparation"

Formed since koalas in NSW, Queensland and the ACT were listed as endangered, a federal koala recovery team has recommended -

"Action 6c: Regionally assess the feasibility, risks and cost-effectiveness of fire management options that seek to deliver long-term, strategic and landscape scale enhancement of the extent, and quality of current and future suitable habitat across tenures."

However, the NPWS's burning agenda remains based on the proposals indicated in the 2018 Bega Valley Bush Fire Risk Management Plan. These proposals appear to be based on a report (Bentley & Penman. 2017) that referred to a book describing broad unlogged vegetation types for NSW and the ACT (Keith. 2004).

Fuel loads are suggested to have been derived from the same source, although there is no mention of fuel loads in the book. The most recent hazard reduction burn in the Murrumbidgee catchment covered 320 hectares and was lit on June 1 2023. The area includes compartments identified with soil erosion from logging undertaken in 1991 (NSW Department of Lands 2006), as indicated in the map below.



Land degradation



Minor sheeting



Moderate sheeting



Severe sheeting



Extreme sheeting



Compartments-coupes

As a consequence of the soil loss and disturbance eucalyptus regeneration has been poor and most of the regrowth in these compartments is black forest oak. This species is frequently the only tree species that regenerates after logging in these forests due to the reduction in soil fertility. Like wattles, black forest oak has bacteria on its roots that enable the take up of atmospheric nitrogen that increases soil fertility over long time periods. The oaks also drop their needles that feed micro-organisms and fungi that are largely responsible for making nutrients available to plants. The needles also assist in retaining soil water content by reducing evaporation.

In a forty year old stand, forest oak needles have been found to weigh 6 kilograms per square metre. Extrapolating to the recently burned 30 year old stands, the weight of needles comes to 45 tonnes per hectare. The burning is likely to consume most of this litter and produce up to 29,700 tonnes of CO₂ in the process. As the average Australian produces about 22.4 tonnes of CO₂ per annum, the burn could produce CO₂ equivalent to that produced by 1,326 Australian in a year. In this case the deliberate burning has set back restoration of lost soil by 30 years.

Much of Murrumbidgee state forest was burned during the Badja fire and the most recent burn adds to this area. It has been suggested that - “Planned burns may help maintain koala habitat by: • encouraging growth of koala feed trees • maintaining appropriate soil environments for koala feed trees • reducing mid-storey competition for nutrients and water.” (NSW Department of Planning and Environment 2022). No references are provided to support these suggestions.

Koalas

“... The koala is an arboreal and folivorous marsupial (Melzer et al., 2000). It is widely distributed in eastern mainland Australia with range boundaries closely linked to climatic conditions (Adams-Hosking et al., 2011, 2012). At extents of 1000s of ha, its occurrence is associated with the distribution of the genera *Eucalyptus* and *Corymbia* (Myrtaceae) (DeGabriel et al., 2010) which occur on relatively fertile soils (Moore et al., 2004; Crowther et al., 2009).” (Adams-Hosking et al. 2016)

The NSW Scientific committee’s final determination (NSW Scientific committee 2007) that koalas in the nominated are are not disjunct from other populations, was based on koala records held in what is now referred to the Bionet Atlas. Many of these records were subsequently revealed to be in the names of various researchers who had never been to the particular forest or seen a koala.

The initial community koala surveys (Phillips, 1997), that defined koala feed tree preferences, were undertaken using the Spot Assessment Technique (SAT), after finding koala pellets during sweep surveys. In 2007, the NSW government implemented these surveys on a regularised grid (RGB-SAT), to determine whether koala tree species use was consistent at a landscape scale.

Having confirmed this was the case, the RGB-SAT surveys were then employed as pre-logging surveys, in Bermagui State Forest during 2010, where a koala had previously been radio-collared (Jurskis & Potter, 1997). No evidence of koalas was found so logging proceeded.

The labour intensive and time consuming RGB-SAT surveys have been ongoing for 26 years. However, there are no records from these surveys on the Bionet Atlas since 2013.

The most recent information on the RBG-SAT surveys indicates -

“Occupancy modelling (accounting for imperfect detection) shows a stable population with a slight growth in the latest monitoring period, however this trend would need to be validated by the next period of monitoring. This trend does not represent a statistically significant (i.e. greater than 30 percent) increase or decrease in koala occupancy rates in the region when compared with previous periods. Despite this, the extinction probability has increased from 35 percent to 50 percent from Period 1-2 and 2-3. This may be a result of increased uncertainty due to sampling rather than the full survey being analysed for Period 3, but will be explored further in the University of Canberra report.” (Natural Resources Commission. 2021)

In 2017 the first acoustic recording surveys were undertaken from the 24th October to the 9th of November at 24 sites on the one kilometre RGB-SAT grid either side of the Murrumbidgee river (Law et al 2019).

The main limitations with the acoustic surveys are that they only identify male koalas and do not provide the direction the call is coming from or distance of the koala from the sound recorder. It was thought that this uncertainty is why the Bionet Atlas provides a site accuracy of 200 metres. Previous koala research in the region found “Bellows may be audible over 2km (pers.obs of the authors).” (Jurskis & Potter, 1997)

Night time rainfall, based on daily rainfall records from the Merimbula airport, some 35 kilometres to the south, was considered to be factor reducing call frequency (ibid). However, daily rainfall records do not differentiate between what falls during the night and day. Rainfall recorded at Wapengo and Merimbula during the survey in October and November 2017, is indicated in the following table, where rainfall for the previous 24 hours was recorded at 9am.

	Date	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8
Wapengo	mm	-	0.8	4.4	34.8	3.2	1.4	-	-	-	-	1	-	-	23.6	53.4	-
Merimbula	mm	-	-	7.6	10.8	-	-	-	2.8	-	-	-	2	-	4.2	28.2	-

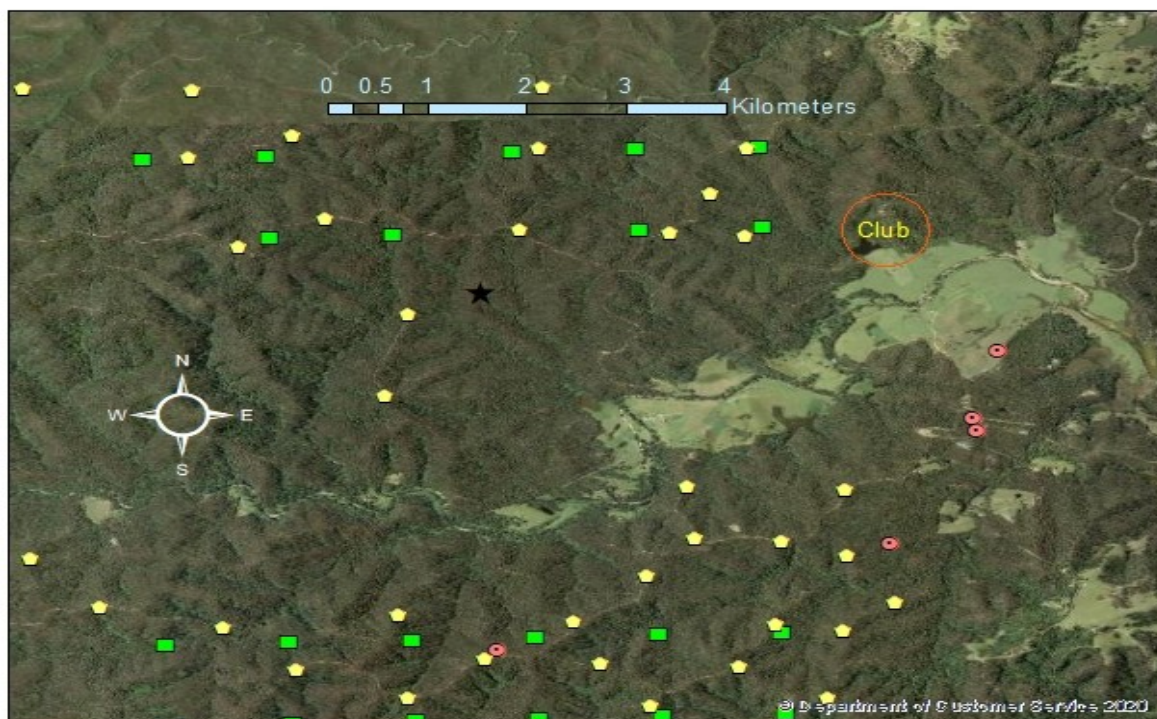
This rainfall was preceded by 14mm in the week before the survey and just 13.5 mm in the 9 weeks prior to that. A lack of rainfall coupled with heatwaves preceded the 25% reduction in koala numbers around Gunnedah in 2009 (Lunney et al. 2012). This research “. . . examined a 1990s success story where the local koala population benefited from the plantings of trees and shrubs to hold down the water table in the face of a rising salinity crisis”. Subsequent research in the area employed artificial water stations to ascertain their use by koalas during a period of 12 month (Mella et al. 2019). This research concluded -

“ . . . Our findings suggest that when temperature is high and rain scarce, koalas intensify their drinking behaviour to sustain their increased water requirements as a strategy to cope with extreme weather conditions. (Mella et al., 2019)

The research recommended “measuring foliar moisture more often throughout the year to ensure that finer changes (if existent) can be detected.” (ibid). Koalas have also been recorded drinking from artificial water stations in Mumbulla state forest, as part of the community ‘Help save the south coast koalas’ campaign⁹. This campaign is not supported by the NPWS and was reported by the government initiated and funded Koala Action Network¹⁰ as “A Knights Creek Rd. resident has filmed koalas on a movement sensitive camera near a water station he has installed.”

Captive koalas have been found to reject leaves below a “minimal or threshold level of water (approximately 55%) (P=0.028) and essential oils (approximately 2% of dry matter) (P=0.044).” (Hume & Esson C.1993). Koalas are known to glean surface water from leaves and where ever else they can, when it is there. It seems likely the reduced number of bellows on days with rainfall (Law et al, 2019) reflects time spent by koalas gleaning water after a prolonged dry spell. To date there has been no research conducted on leaf water content, during dry or wet periods. In the absence of appropriate research, a reduction of leaf water content can only be observed when the leaf begins to wilt.

The following map indicates location of koala records since 2013 and their proximity to the shot gun club. The green squares are from the initial acoustic surveys (ibid), where calls were recorded at 9 sites north of the Murrumbidgee river, including the Cuttagee catchment and 12 sites south of the river including the Wapengo catchment.



- | | | |
|-----------------------------|---------------------------------|--|
| 2013-2023 koala recs | State Forests Biodata | DPIE Data from Scientific Licences dataset |
| DATA SET | South Coast Acoustic Monitoring | 2019-21 Community Wildlife Survey |
| Wildlife Rehab Database | DPIE Default Sightings | |

9 <https://bertramr.files.wordpress.com/2021/02/hssck-report.pdf>

10 <https://www.koalaactionnetwork.org/>

“ . . . Passive acoustic surveys commenced as part of the monitoring program undertaken by the Department of Planning, Industry and Environment (DPIE) in spring 2016 at 24 of the study area’s scat sites. Passive acoustic surveys have subsequently been undertaken in an additional two sub-areas in the spring of 2017, 2018 and 2019. (Natural Resources Commission. 2021)

While the timing of the surveys in the quote above may not be correct, the publicly available records, from more recent acoustic surveys are indicated in Map 1. The more numerous koala records on the map/s (yellow pentagons) are referred to as the South Coast Acoustic Monitoring survey, although the survey sites appear not to be based on a grid. These records are given a location accuracy of 10 metres and sites where bellows weren’t recorded are not available.

Most of the other records on the map (red circle with black dot) are from what is broadly referred to as Community Wildlife Surveys. The closest of these to the club is reported to be a dead koala along the Bermagui-Tathra. Just to the south are two records south of the Murrah hall. These records are also given a locations accuracy of 10 metres, although previous community koala records were given a location accuracy of 10,000 metres.

However, more accurate records are from koalas reported by a member of the Rural Fire Service, in 2020 on private land adjacent to and on the northern side the Murrah hall. Media coverage¹¹ of the sighting indicated-

“ . . . A mother koala and her joey spotted in a stringybark tree on private property in the Murrah Forest on February 10 have stayed put, sparking concerns for their health.

“This is contrary to everything we thought we knew about Far South Coast koalas. They usually change trees two to three times per night to feed,” Chris Allen of the Koala Action Network says.

Found a few kilometres from the Badja Forest firefront active in the nearby Murrah Flora Reserve, Chris and other koala experts have been concerned the koalas could be sick, injured or traumatised.

“We still don’t know for sure how affected by the fire these koalas are. We can see that one of the mother’s paws is very pink, which may be a burn, and she has one milky eye. It’s so unusual for them to be in one place this long, we wonder if she in shock and recovering,” Chris comments.”
(About Regional. 19 February 2020)

Under normal circumstances a koala in a tree for 11 days, with a foot injury consistent with a burn and a milky eye, consistent with symptoms of Chlamydia, would have been flagged down the tree and taken to a veterinarian. This would seem particularly the case given the uncertainty about whether the koala came from north of the Murrah river, where Chlamydia has been identified in koalas.

While it seems improbable that the koala carrying a joey walked several kilometres through unburnt forests, crossing the Murrah river and negotiating barbed wire fences from where back-burning was being undertaken in Murrah State Forest. In the absence of evidence to demonstrate otherwise, the failure to take the koalas into care may have introduced Chlamydia to koalas south of the Murrah river.

In June 2021 a koala was sighted in a Mountain grey gum (*E. cypellocarpa*) on private property some 4.3 kilometres west of the Murrah hall. This koala stayed in the tree for four days, although it moved through the branches to roost in adjacent tree on two days. During this time several hundred koala pellets were deposited under the tree, that had some post drought epicormic growth. Since that time the koala has returned to the area on at least three occasions, although on each occasion a different tree has been browsed and the first tree has not been browsed.

Another koala reported in local media was sighted south of the Murrah hall in September 2020¹². This record is some 80 metres from the closest Bionet Community Wildlife survey record.

11 <https://aboutregional.com.au/mum-and-joey-koala-found-in-the-murrah-get-expert-help/>

The RGB-SAT survey results over the past decade are not featured in the Bionet Atlas seemingly because they provide a more accurate location on where evidence of a koala was found. The current prescriptions for logging in the Eden region do not require Forestry Corporation to look for koalas in compartments where there are no koala records for the past decade.

Koala habitat restoration

“. . . Agency staff and contractors working on koala surveys (1996-8, 2007-9 and 2012-14) have repeatedly observed that many areas throughout the Murrah Flora Reserves have a modified floristic composition and structure apparently due to disturbances including harvesting and fire. These areas are dominated by dense black she-oak, silvertop ash and/or stringybark regrowth, which contributes to higher vertical fuel-loads and suppresses the regeneration of koala browse species, particularly woollybutt. (State of New South Wales and Department of Planning, Industry and Environment 2019)

The first government trial project to restore koala habitat was, as indicated in the quote above, based on the belief that the successional species, particularly black she-oak and silver-top ash suppresses the regeneration of koala browse species. The project planned for 23 20 x 30 metre plots, mostly in Murrah state forest and the works began prior to a Review of Environmental Factors being completed (Envirokey. 2017). Nine of the plots were to be burned and there were 4 control plots.

Having identified logging and fire as an apparent cause of the poor regeneration of woollybutt, the most preferred koala feed species, the trial involved a mix of clearing black she-oak and thinning silvertop-ash, burning, no burning and seeding where no koala feed trees were present.



The photo above shows one of the plots some months after thinning in Murrah state forest. Black forest oak generally does not coppice after being cut down, although silver-top ash and other eucalypts do. While it is apparent this probable outcome was not considered, the significant loss and degradation of soils from logging and burning was also not considered.

It has been suggested that the failure of koala feed trees to grow was due to ‘hungry wallabies’. During a visit to observe one of the community water stations a threatened species officer involved in the project referred to the plots saying they were ‘wondering what to do with them’(pers.comm R. Pietsch -24/10/2019).

The review of environmental factors for the project did not include consideration of soils or their limitations suggesting only that “Soils consist of thin stony red and red-yellow texture-contrast soils. These soils are considered moderately erodible when exposed to significant surface disturbance.”

Since that time most of the locations in Murrah state forest were burnt during the Badja fire (Map 6). Despite the apparent failure of the methods employed to restore koala habitat, it has been suggested that -

“. . . Additional funding is needed to continue to support novel management approaches to increase the viability of the local koala populations.⁵¹ For example, NPWS are undertaking a research trial using treatments to shift the current vegetation composition towards species that are preferred koala browse trees. Treatments include fire, vegetation thinning, ground litter manipulation and direct seeding. These active intervention trials are ongoing, however treatment areas were impacted by the 2019/20 wildfires.”(Natural Resources Commission. 2021)

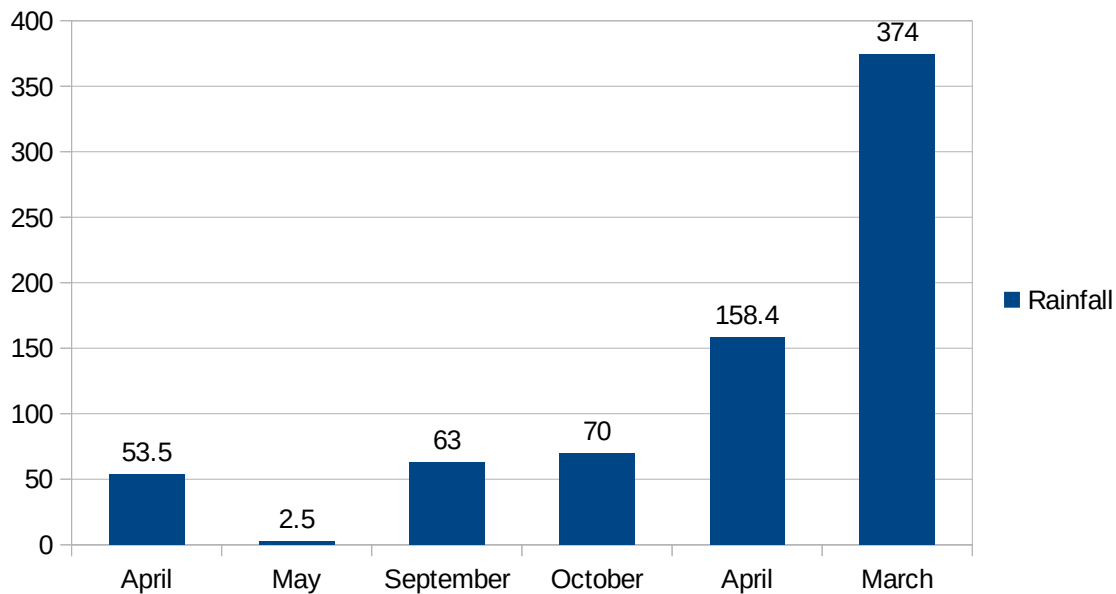
An alternative approach could have been to thin to the largest trees along roads in order to prepare for back-burning and assist in restoring the original hydrological regime by promoting the growth of larger trees (Bormann & Kiestler 2004). The first suggestion that burning would improve forest health was put forward by former NSW Minister Ian MacDonald in 2006 (Attachment 4).

Water sources

Three sources of water are recognised in the Murrah catchment being surface water, alluvium/coastal sands and groundwater from the Lachlan Fold Belt coast groundwater source. There are five registered bores in the Murrah catchment, three of which are indicated as being 5 metres deep, seemingly drawing from alluvium or coastal sands, but there is no description of water quality from these bores. Another two are indicated as being 30 and 50 metres deep with standing water levels of 11 and 11.5 metres respectively. The only indication of water quality is for the former bore indicating “salinity-good”.

Rainfall

The following chart provides rainfall in millimetres, recorded at the Murrah for the two months prior to the ERM study (April and May 2021), the sampling reported here (September and October 2021) and subsequent observations of turbidity at three sites (April and March 2022).



Community water sampling

The most recent advice on water sampling indicates -

“ . . . Default guideline values (DGVs) can provide you with an important starting point for managing water quality but they cannot account for the large spatial or temporal variation in natural water quality. This includes variation in environmental variables that influence the bioavailability and toxicity of contaminants.

Toxicant DGVs are based on data from a specific set of solution parameters, such as pH, hardness, dissolved organic carbon, salinity and temperature. These characteristics vary widely throughout Australian and New Zealand waters.

In addition, DGVs may not protect locally important species because published global data are usually only available for a very limited number of (usually standard) toxicity testing species. Very few of them are Australian or New Zealand species. This is why you should, wherever possible, tailor DGVs and the types of water chemistry data collected to account for local conditions. The ultimate tailoring of a DGV to local conditions is the derivation of a site-specific guideline value.”

Eight sites were selected upstream of the club in Mumbulla creek, the Murrah river, Knights creek and a smaller sub-catchment. Two sites were intended below the club with one in Arnolds gully and one in the Murrah river. However the landholder would not give permission for water sampling in Arnolds gully, so the site AG1 was moved closer to the ERM study site SW1.

Samples for Electrical Conductivity, lead and antimony were collected from just below the surface (10cm), placed directly into the laboratory supplied sampling containers and chilled.

Results

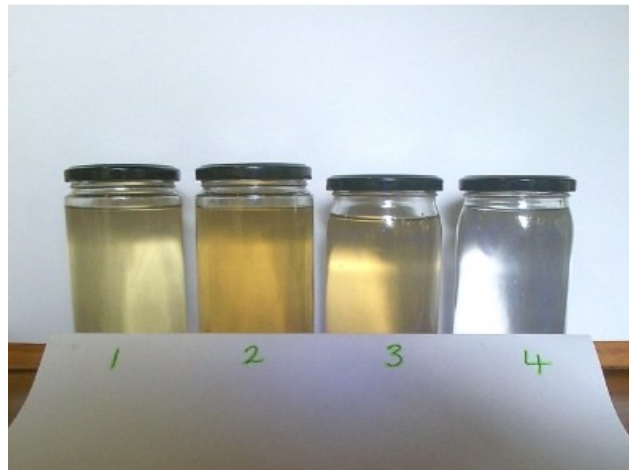
Analysis of water sample was undertaken by the National Measurement Institute (Appendix 1) and all results for antimony and lead were below $1\mu\text{g/L}$. The table below provides the results, moving from west to east for Electrical Conductivity per site (Map 1).

Site	MC1	MR1	KC1	PC1	MR2	MR3	AG1	MR4	MR5	MR6
E/C	120	200	290	300	210	210	340	450	220	390

While the Mumbulla creek catchment and all areas west and north were burnt during the Badja fire, this site had the lowest E/C. Site MR6, which is below Arnolds gully, was the exception for flowing

water in the Murrah river, with E/C at sites MR1, MR2, MR3 and MR5 being the same or similar. In contrast, E/C in all sub-catchment pools at sites KC1, PC1, AG1 and the pool without flow in the river bed, site MR 4 were all more than double site MC1 and around 50 to 75% greater than most river E/C levels.

The following photo shows water clarity samples taken during elevated flows on April 8 2022. Number 1 is from Mumbulla creek (2,103 ha.) number 2 at Knights creek (812 ha.), up stream of the site KC1 due to accessibility constraints and number 3 from the unnamed creek (181 ha.) at site PC1. Number 4 is rainwater.



A secchi disc was employed at sites KC1 and PC1 during sampling when water at the latter site appeared more turbid, but the disc was still visible at 80cm deep. On the second visit during higher flows KC1 wasn't accessible. At site PC1 the disc had vanished from view at a depth of 60cm.

Discussion

“Lack of identification in the report of any hazardous or toxic materials on the subject Site should not be interpreted as a guarantee that such materials do not exist on the Site.” (the study)

It is most unlikely that 30+ tonnes of lead could not have a negative environmental impact, both in the area it has been deposited and if not already, eventually the supposedly protected coastal zone that covers part of the club's land. The limitation on when this will occur is largely due to the poorly understood rate at which lead pellets will breakdown. What is known is that the breakdown of lead occurs faster in acidic soils that are a consistent feature of the Murrah soil landscape.

In addition to local government, the role of state government agencies, the EPA and the NPWS in the approval for more shooting tends to confirm a low level of understanding and compliance with their own guidelines and legislated responsibilities. Support from these state government agencies has clearly provided the confidence for BVSC to ignore all the information provided by the community about the negative environmental and social impacts of the gun club.

Similarly, claims of ecologically sustainable management in public native forests are based on a selective and limited incorporation of credible environmental science and a poor understanding of ecological processes. This approach is consistent with repeated messages from the Rural Fire Service during the Badja fire that, ‘the environment comes last’.

According to the Murrah Flora Reserves final draft management plan¹³ :

13 https://www.forestrycorporation.com.au/__data/assets/pdf_file/0008/1323728/murrah-flora-reserves-working-plan.PDF

“ . . . Impacts on koalas and their habitat from clearing, other land-use and environmental changes (temperature increase and drought) have been significant contributors to the decline of koalas in the Eden region (Lunney et al. 2014)

Within this context wildfire (and associated reactive management) and predation are probably the most immediate and major threats to the Murrah koala population. However, should the higher temperatures and more severe periods of drought predicted for the region (OEH 2016c) occur, additional declines are likely to occur, particularly due to wildfire, degradation of browse quality (Lawler et al. 1997) and defoliation (Jaggers 2004). Changes in other more complex threats such as dieback are less clear.”

With regard to the first reference (Lunney et al. 2014), previous work by the author (Lunney & Leary 1988) reported koala numbers increased to ‘plague’ proportions on agricultural land in the 30 years after most of the clearing had been undertaken. This increase could only occur if the preferred koala feed trees were growing back and/or coppice growth on trees cut down was sustaining the significant increase in koala numbers. Either source of food for koalas would require sufficient soil fertility to sustain the growth. Koala extinction was reported to have occurred between 1905 and 1909 when they looked “very sick and dejected in the trees before they were found in hundreds dead at the foot of trees” and “ The popular belief was that they were stricken with a disease which resulted in paralysis and eventual starvation”

Eight droughts were recorded between 1840 and 1909 although the one before 1909 was in 1898 and doesn’t coincide the sudden loss of koalas. Other land use includes logging and burning, both of which reduce soil fertility, such that preferred feed trees cannot provide the nutrients and don’t grow back. However, the first paper “emphasised the importance of managing both the species and the ecosystem holistically over long time periods.” (Lunney et al. 2014)

The suggestion that wildfire is one of the ‘most immediate and major threats’ tends to ignore the process of soil degradation and associated reduction in soil fertility. These factors do lead to increased flammability when leaves turn brown. There is no evidence that predation is an immediate threat to koalas. Environmental or climate change is a global issue that isn’t directly related to the reduction in soil fertility at a local landscape scale.

Tree defoliation (Jaggers 2004) is dieback associated with dry weather and drought. This change is the more complex threat that is less clear to the NSW government, because the EPA doesn’t agree with the science and all the other agencies follow its lead.

In the apparently temporary moratorium on logging, the focus is on so called ‘hazard reduction’ burning. The belief that this management will both increase koala habitat and protect them from unplanned burns is not supported by credible environmental science. The significant public funds spent on lighting fires, neglects the fact that it given the right conditions it will burn again. Like logging the planned lighting of fires also ignores the negative impacts on soils.

The degradation of soils due to erosion and dispersion has been ongoing for several decades. Ignoring this issue makes as much sense as claims lead levels in and around the gun club are no more abundant than background levels.

It seemly likely that at least \$20 million of public funds has been spent on the south coast koala ‘issue’. Unfortunately these public funds have not been aimed at either understanding or mitigating the main threat to the species. The long-nosed potoroo is also claimed to be protected in in the Murrah flora reserves. Yet there have been no surveys for the species, there is no feral predator control program and both the Forestry corporation and the NPWS oppose community efforts to restore the biodiversity required to improve forest health.

While it remains the responsibility of the community to prevent and mitigate land degradation, it would be helpful if credible science featured in the beliefs of those arguably employed to maintain biodiversity and mitigate threats.

An approach to forest management that aims toward restoring forests by employing environmental science within a more balanced consideration of environmental, social and economic outcomes has been proposed (Kenowski et al. 2022). In the absence of such an approach forests across tenures will continue to decline, fires will become more intense and further extinctions of native flora and fauna is certain.

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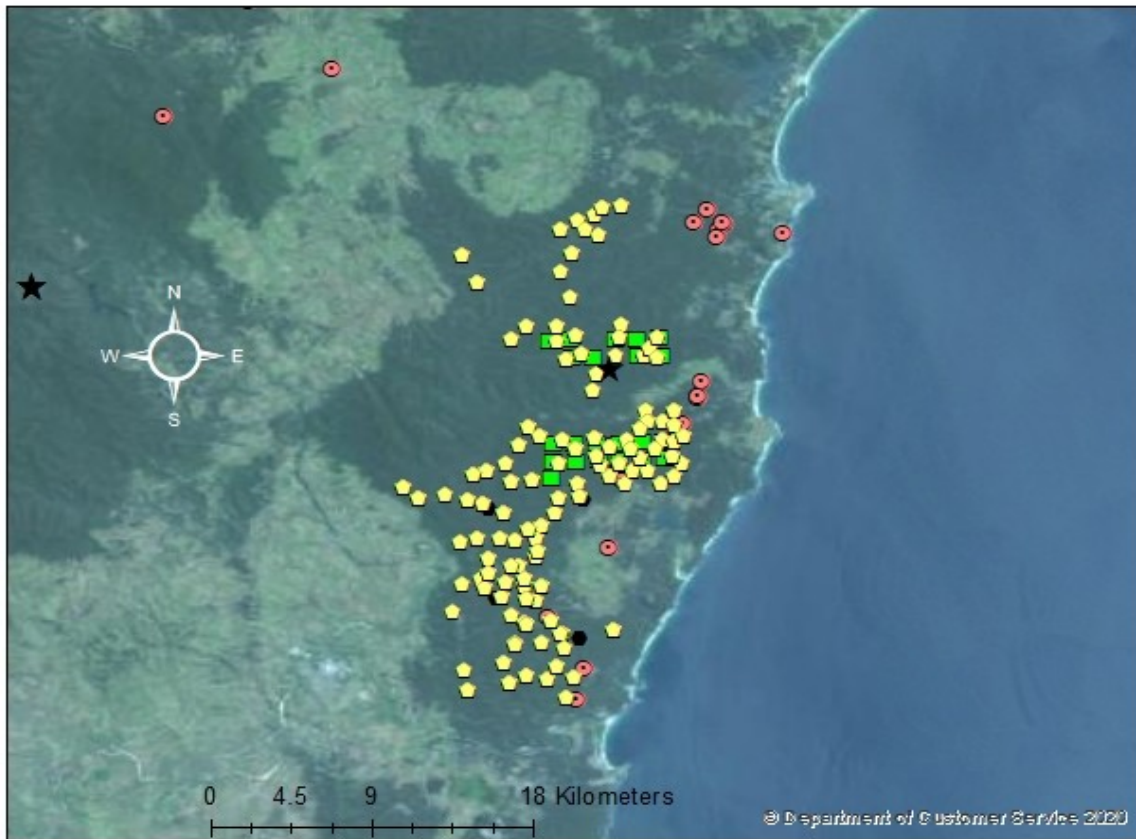
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Maps

Map 1 - Koala records post 2013



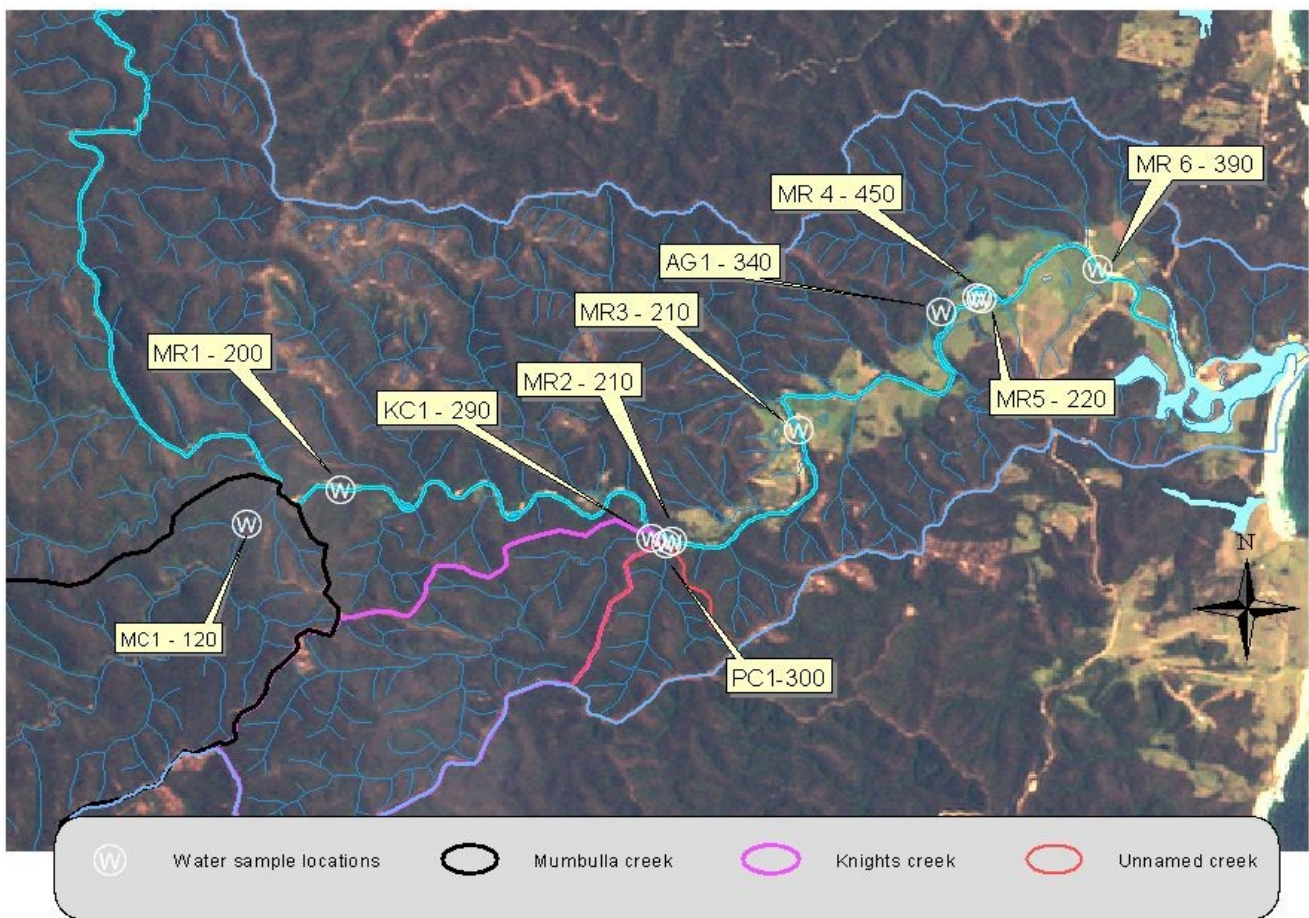
2013-2023 koala recs

DATA SET

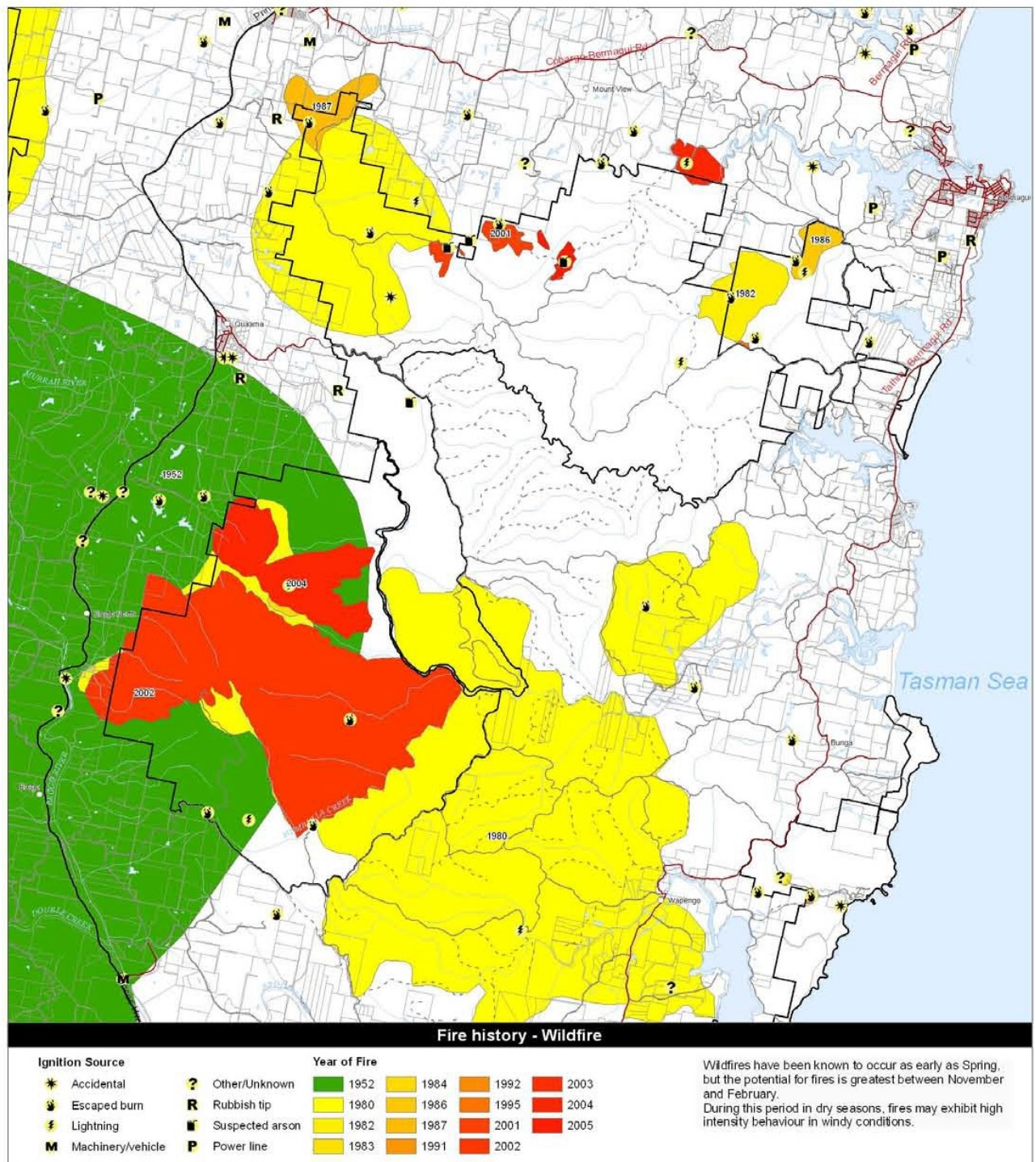
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|---|--|
|  State Forests Biodata |  DPIE Data from Scientific Licences dataset |
|  South Coast Acoustic Monitoring |  2019-21 Community Wildlife Survey |
|  Wildlife Rehab Database |  DPIE Default Sightings |

Map 2 – Electrical conductivity – community results

Murrah catchment - water Electrical Conductivity



Map 3 – Murrah fire history -unplanned burns



Map 4 – 1980 fire in Mumbulla

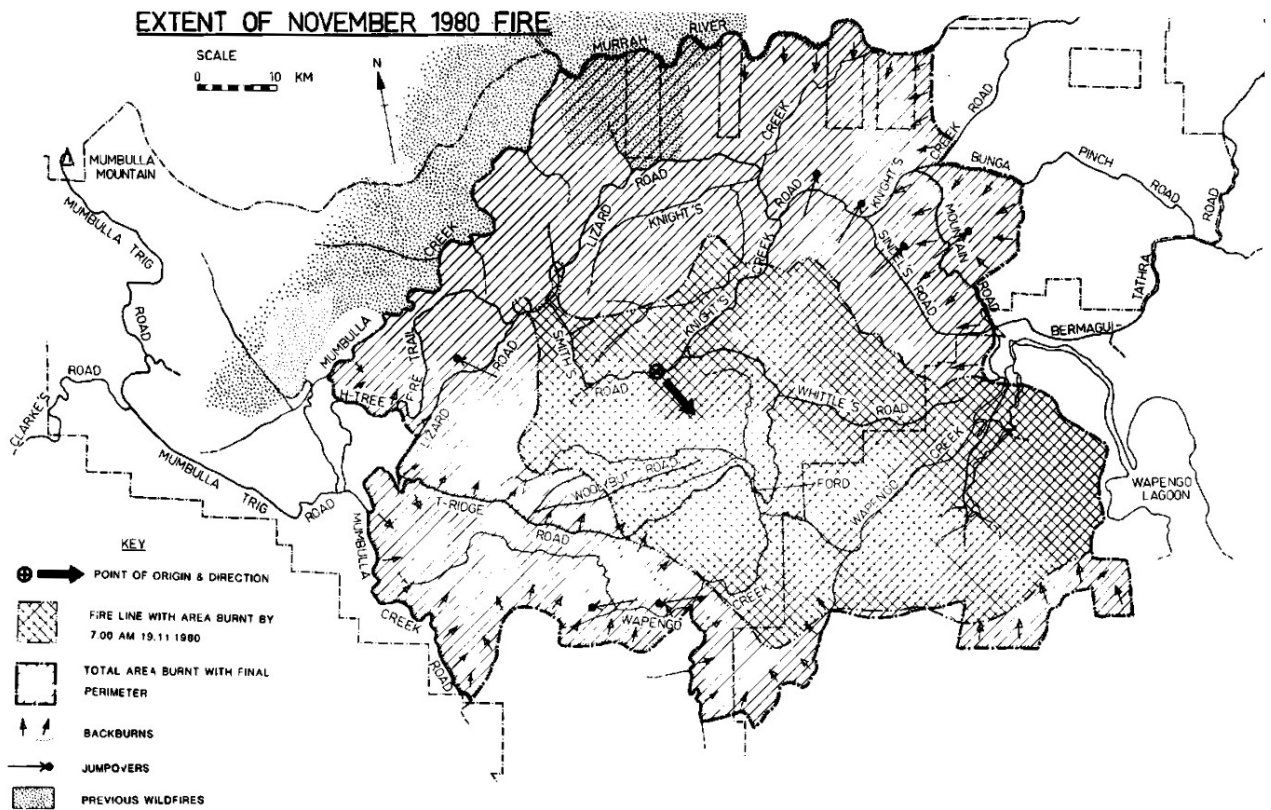
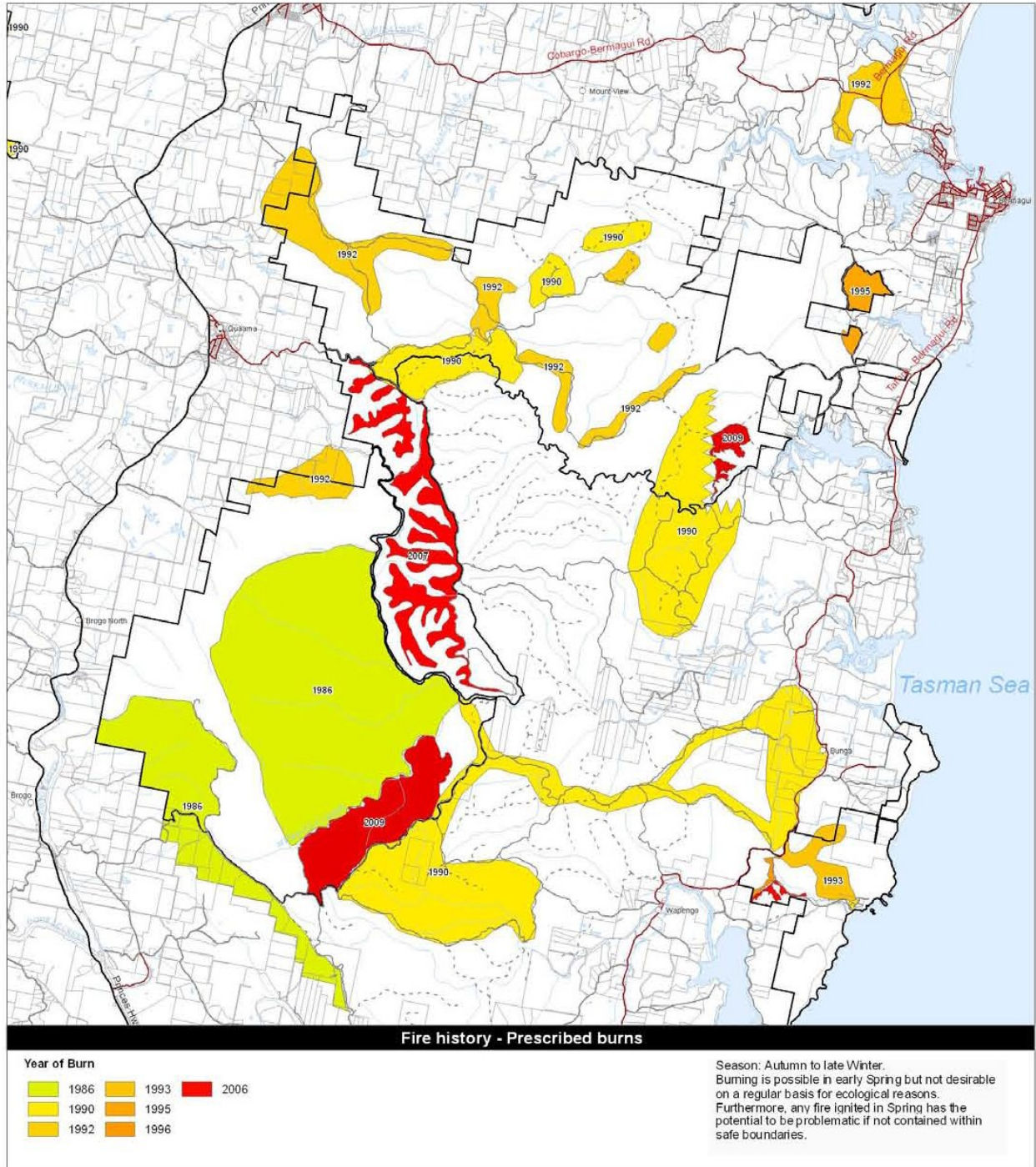
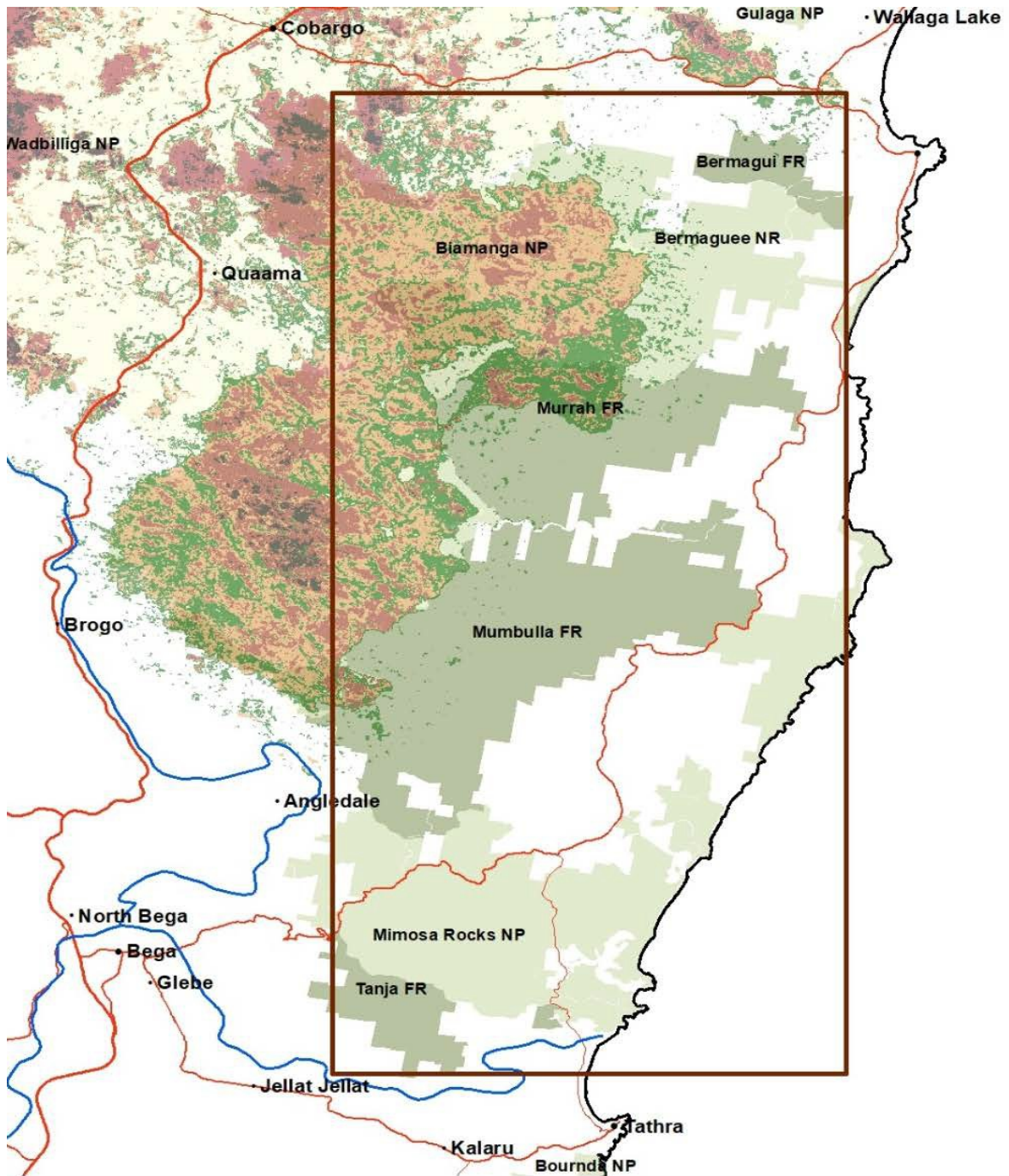


Fig. 23 The extent of the fire which began in the late afternoon of 18/11/1980. The map shows the point of origin and direction, the area of initial burn (to 7 am, 19/11/1980), and the course of the fire, including back burns, jumpovers and area of total burn. An earlier fire in June-July 1980 on the northern edge of the forest is also shown (Source: Forestry Comm., NSW)

Map 5 - Planned burns pre-2007



Map 6 – Badja fire extent- severity



- Legend**
- Urban
 - Non-FESM burnt areas
 - Low - burnt understorey with unburnt canopy
 - Medium - partial canopy scorch
 - High - full canopy scorch/partial consumption
 - Extreme - full canopy consumption
 - No data
 - NPWS Estate
 - NPWS Acquired Not Gazetted
 - NPWS Managed Crown Land

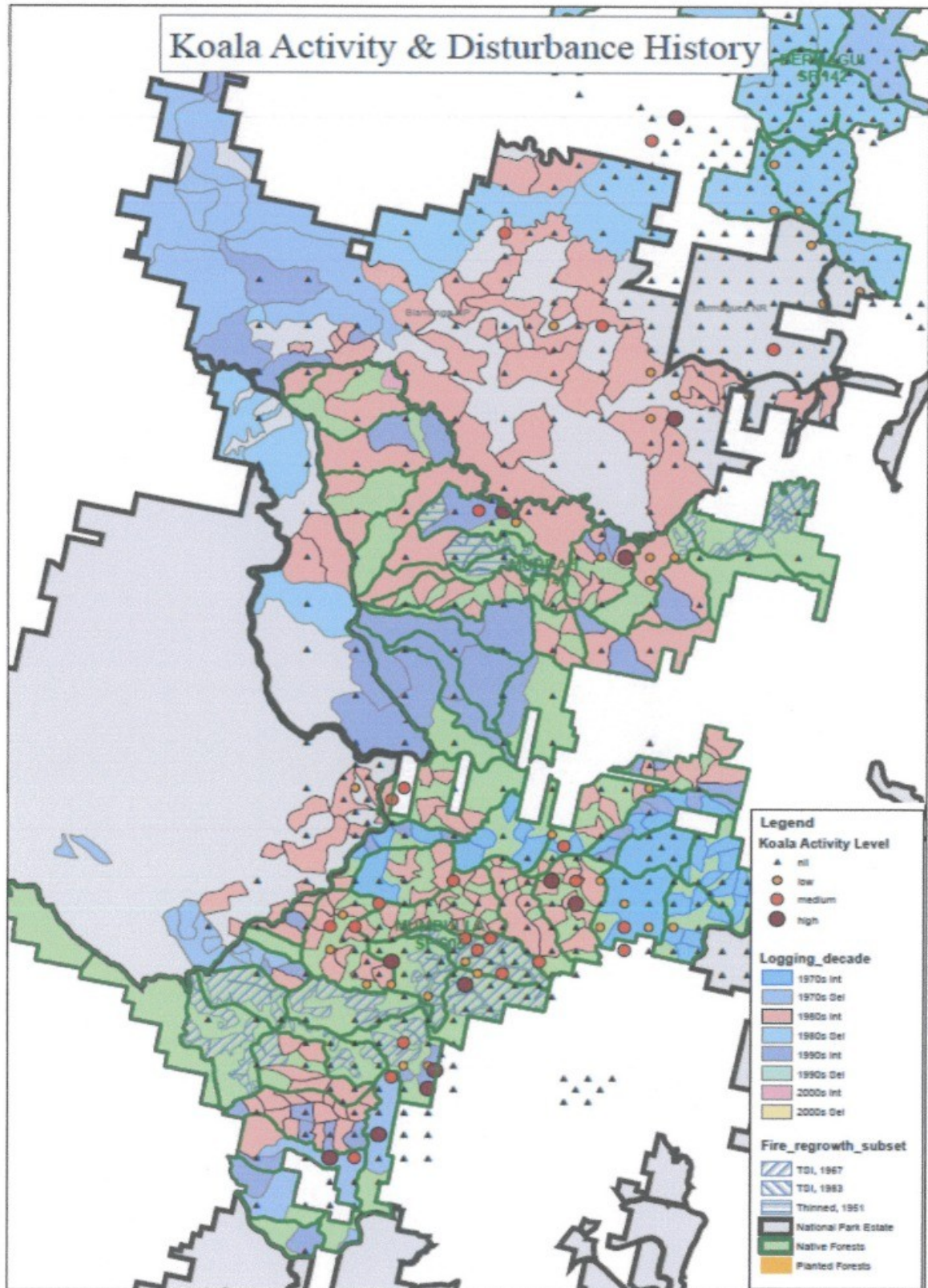
**Far South Coast Koala Study Area
Fire Extent and Severity Map
August 2020**

Copyright of Department of Planning, Industry and Environment.
This map is not guaranteed to be free from error or omission. The Department and its employees disclaim
liability for any act done on the information in the map and any consequences of such acts or omissions.

Scale 1:50,000
Datum/Projection: GCS GDA 1984



Map 7 – Logging history



Site photographs

Mumbulla creek site – MC1 with moderate flow



Mumbulla creek site – MC1 with higher flow



Murrah river – site MR1



Murrah river – site MR2



Knights creek – site KC1



Unnamed creek - site PC1



Murrah river – site MR3



Murrah river – site AG1



Murrah river – site MR4



Murrah river – site MR5



Murrah river – site MR6



Knights creek – site KC2 during higher flow



Unnamed catchment – site PC1 during higher flow



Unnamed catchment – site PC1 with Secchi disc disappearing



Unnamed catchment – site PC1 with Secchi disc reappearing



Attachment 1

DOC19/675638-6
Ms Cecily Hancock
Planning Coordinator
Bega Valley Shire Council
PO Box 492
BEGA NSW 2550

Via email: chancock@begavalley.nsw.gov.au

Dear Ms Hancock

RE: EPA Advice - Assessment of Lead Contamination at the Bermagui Gun Club Shooting Range, Murrah Road via Bermagui

Thank you for discussing this matter today 26 September 2019 with Regional Operations Officer Tristan Johnston. I also refer to Bega Valley Shire Council's (BVSC) request to the Environment Protection Authority (EPA) via email on 15 April 2019 seeking general advice on assessing land contamination at shooting ranges in NSW as well as various subsequent emails, telephone calls and teleconferences discussing assessment of land contamination specifically at the above premises.

The EPA has responsibility for regulating certain activities under the *Protection of the Environment Operations Act 1997* (POEO Act), and for regulating significantly contaminated land under the *Contaminated Land Management Act 1997* (the CLM Act). As you are aware, the site is not regulated by the EPA via the POEO Act or the CLM Act.

Background

In considering the request for advice, the EPA understand that:

- The proponent (Bermagui Gun Club) is seeking to increase shooting days from 12 to 24 per year;
- The Murrah Resident Action Group Inc. (MRAG) submitted a report that includes sampling at four locations outside the Bermagui Gun Club clay target area. Lead concentrations at these four sampling locations were below 300mg/kg (Health Investigation Level – residential criteria).
- Previous on-site sampling conducted in January 2010 assessed multiple pollutants.

Based on the information provided by BVSC and MRAG, the EPA recommends that, in assessing the development application, Council consider the suggested conditions in Attachment A of this letter. Thank you for discussing this matter with the EPA. If you have any queries or wish to discuss this matter further, please contact Tristan Johnston or myself on (02) 6229 7002 or via queanbeyan@epa.nsw.gov.au.

Yours sincerely

MATTHEW RIZZUTO
Unit Head – South East Region
Environment Protection Authority

Attachment A – NSW EPA Recommendations

Assessment of Lead Contamination at the Bermagui Gun Club Shooting Range, Murrah Road via Bermagui

1. The proponent to engage a consultant to conduct a baseline contamination study at the site. Bermagui Gun Club and Council may refer to EPA Victoria's *Guide for Managing Contamination at Shooting Ranges* <https://www.epa.vic.gov.au/~media/Publications/1710.pdf>. Section 3 of this guide provides advice on assessing the contamination risk when dealing with shooting ranges. 1.1. Council should note that the contaminants resulting from shooting activities, include primarily lead but also others such as polycyclic aromatic hydrocarbons (PAH), copper, zinc, antimony, arsenic, nickel, tin, strontium, magnesium, barium, and mercury. The soil (and water samples if applicable for this site) should be analysed for these contaminants of concern for the baseline contamination study.

1.2. In addition to the above, the following analytes (pH, suspended solids, texture, TOC solids, total lead, total dissolved solids, total nitrogen, total phosphorus, and chlorophyll 'a') may also be analysed to enable comparison against the previous data collected on-site in January 2010.

2. The purpose of the baseline contamination study is to assess the levels of these contaminants of concern at the site and to determine if there are any complete 'source-pathway-receptor' scenarios resulting from the activities undertaken in the shooting area. The EPA suggests that the following guidance, as relevant, should be considered, when assessing contamination at the site:

- *NSW EPA Sampling Design Guidelines*

www.epa.nsw.gov.au/resources/clm/95059samppgdline.pdf

- *Guidelines for the NSW Site Auditor Scheme (3rd edition) 2017*

<https://www.epa.nsw.gov.au/publications/contaminatedland/17p0269-guidelines-for-the-nsw-site-auditor-scheme-third-edition>

- *Guidelines for Consultants Reporting on Contaminated Sites, 2011*

[https://www.epa.nsw.gov.au/~media/epa/corporate-site/resources/clm/20110650consultantsreportglines.pdf?](https://www.epa.nsw.gov.au/~media/epa/corporate-site/resources/clm/20110650consultantsreportglines.pdf?la=en&hash=ADA6F5BEA134F3E87217764484F14618E40C98EA)

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- *The National Environment Protection (assessment of contamination) Measures 2013 as amended* <http://www.nepc.gov.au/nepms/assessment-site-contamination>

3. The proponent to ensure that any contamination identified as meeting the trigger in the EPA 'Guidelines for the Duty to Report Contamination' is notified in accordance with requirements of section 60 of the *Contaminated Land Management Act*; and

4. The proponent to ensure that the proposed development does not result in a change of risk in relation to any pre-existing contamination on the site so as to result in significant contamination [note that this would render the proponent the 'person responsible' for the contamination under section 6(2) of CLM Act].

5. Council to follow the processes outlined in *State Environmental Planning Policy 55 - Remediation of Land (SEPP55)*, and assess the suitability of the land and any remediation management required in relation to the proposed use.

Attachment 2



Our reference: DOC21/889109
Date: 12 October 2021

Robert Bertram
Bertramr55@gmail.com

Dear Mr Bertram,

RE: Concerns of lead and antimony pollution in the Murrumbidgee river

I writing to you about the email you sent to the NSW Environment Protection Authority (EPA) on 23 September 2021 regarding concerns about lead and antimony pollution in the Murrumbidgee river between Tathra and Bermagui on the NSW South Coast. I also refer to the document titled 'Baseline Contamination Study – Bermagui Sporting Clays' (the contamination study) dated 10 July 2020 that was attached to your email, the contamination study was conducted to assess contamination levels of the Bermagui Sporting Clays club grounds (the site). I also refer to your discussion with the EPA on 12 October 2021.

The EPA has responsibility for regulating certain activities under the *Protection of the Environment Operations Act 1997* (POEO Act), and for regulating significantly contaminated land under the *Contaminated Land Management Act 1997* (the CLM Act). The site is not regulated by the EPA via the POEO Act or the CLM Act. In this instance, Bega Valley Shire Council is the appropriate regulatory authority for this site.

Notwithstanding, the EPA has reviewed the contamination study having regard to your concerns about antimony and lead contamination within the Murrumbidgee River. In reviewing the contamination study, the EPA has found that:

- Antimony was not found at detectable levels in any of the sediment samples, soil samples or surface water samples collected in and around the Murrumbidgee River.
- All surface water lead results in and around the Murrumbidgee River were below ANZG 95% Protection Values for marine waters and fresh waters (3.4 µg/L and 4.4 µg/L respectively). Additionally, the EPA notes that the surface water sample collected upstream of the site, 'SW01', had the highest lead level of 3 µg/L.
- All surface water lead results are significantly lower than the water quality trigger values for livestock drinking water of 100 µg/L (ANZG, 2018).
- Sediment samples collected in and around the Murrumbidgee River had lead results that are significantly lower than the 'Recommended default guideline values for toxicants in sediment' for Lead – 50 mg/kg (ANZG, 2018).

Phone 131 555
Phone 02 8220 7002

TTY 133 677
ABN 43 602 285 758

PO Box 622
QUEANBEYAN
NSW 2620

Level 3, 11 Farrer Place
QUEANBEYAN NSW
2620 Australia

info@epa.nsw.gov.au
www.epa.nsw.gov.au

- Soil samples collected around the Murrumbidgee River had significantly lower lead results than the Investigation levels for 'National park and areas with high ecological value' - 470mg/kg - outlined in Table 1B(4) of the *National Environment Protection (Assessment of Site Contamination) Measure April 2011 Schedule B1 – Guideline on Investigation Levels for Soil and Groundwater* (NEPM, 2011).

With consideration of the above, the EPA notes that there is no evidence of lead and antimony contamination within the Murrumbidgee River. With all samples in and around the Murrumbidgee River significantly lower than the relevant guideline values.

As discussed, the EPA has notified Bega Valley Shire Council as the POEO Act and CLM Act regulator of the site about your concerns.

Thank you for discussing this matter with the EPA. If you wish to discuss this matter further please contact Andreas Stricker on (02) 6229 7002 or at info@epa.nsw.gov.au.

Yours sincerely,



Matthew Rizzuto
Unit Head

Regulatory Operations – Regional South

Attachment 3

-----Original Message-----

From: Fowler, Mark [mailto:mfowler@begavalley.nsw.gov.au]

Sent: November 13, 2018 12:18 PM

To: Alan.Henderson@environment.nsw.gov.au [mailto:Alan.Henderson@environment.nsw.gov.au]

Subject: HPE CM: DA1999.1438 Clay shooting - Bermagui Field & Game club - Modification

Hi Alan,

Thanks for phone call today regarding the Bermagui Field and Game Club. Please find attached a copy of additional comments provided by the Club regarding their management of identifying koalas on-site. It would be appreciated if you could advise in writing of your Departments review of the need to undertake noise testing for koalas.

Finally, please find attached a plan highlighting the location of sediment traps located on-site having regards to the current lot boundaries.

If you require any further information, please give me a call or email.

Regards



Mark Fowler
Senior Town Planner

PO Box 492, Bega NSW 2550
P. (02) 6499 2107 M. 0428 283 973
E. mfowler@begavalley.nsw.gov.au

www.begavalley.nsw.gov.au

We wish to acknowledge the Traditional Custodians of the lands and waters of the Shire - the people of the Yuin nation and show our respect to elders past and present.

Check out all the latest news and events at Council on www.begavalley.nsw.gov.au.

Proposed Safety & Training Day.

Dear Mark,

Bermagui Sporting Clays, formerly Bermagui Field & Game, takes its D.A. requirements very seriously.

When we were first given consent to shoot, one day per month, 20 years ago, by B.V.S.C. , one of the conditions that we had to adhere to was, that before every shoot we had to do a walk around the shooting ground and have a visual inspection of the area ,to make sure that there were no koalas present on the day.

This has been done on every occasion since our inaugural shoot.

The inspection is carried out by a highly qualified member of our club , who usually takes one or two members with him ,to show them what to look for, (our members enjoy this tutoring).

The trees in which Koalas mainly feed ,in this area ,are, Stringy Bark, Woollybutt , and Monkey Gum. We have small scatterings of Stringy Bark and Woollybutt on our property , to which we pay particular attention, but ALL tree varieties are checked , just in case.

The things we usually look for are :

1. Any unusual lump or movement ,either out on the branches or, in the forks of the trees , (feeding or resting koalas).
2. Scratch marks at the base area of the tree trunks, where the Koalas begin their climb.
3. Koala scat in the immediate area of the tree base.

After 20 years of continual observations we are yet to find any sign of a Koala.

If given the opportunity to hold a Safety & Training Day (one day per month) our members would gladly continue this format.

We realise that the area in which we shoot is extremely sensitive and hosts a variety of wild life, and we are well aware of their presence.

Only last month a shooting station was moved when we realised there was a nesting mudlark in the area.

As you can see Mark, Koala sightings have been zero in 20 years of gun club operation and we can see no reason why a Safety & Training day (once a month) ,would have any impact on the areas existing wildlife population.

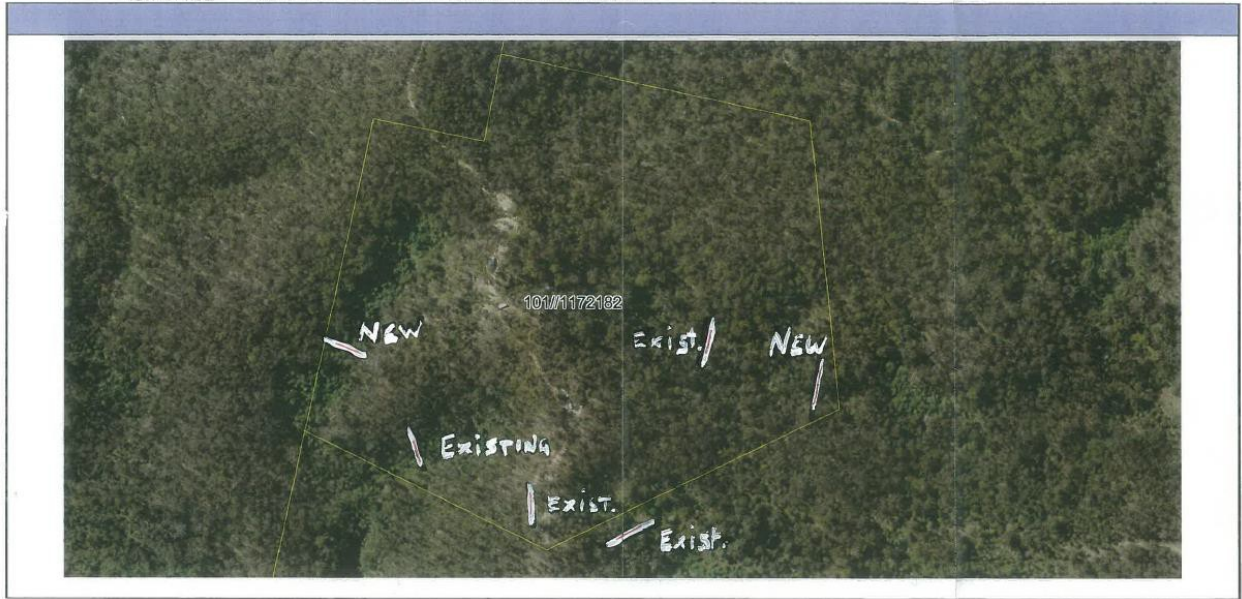
Yours Sincerely

Nev.Brady

President B.S.C.

13 JUNE 2013

NEW & EXISTING SILT BARRIERS AT BERMAGUI FIELD & GAME PROPERTY — MURRAH RIVER ROAD
NEW — INSTALLED 2013, AFTER LAND PURCHASE
EXISTING — INSTALLED 1998 PRIOR TO LAND PURCHASE



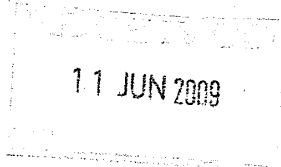
Attachment 4

MINISTER FOR PRIMARY INDUSTRIES
MINISTER FOR ENERGY
MINISTER FOR MINERAL RESOURCES
MINISTER FOR STATE DEVELOPMENT



NEW SOUTH WALES

MPI09/1600



Level 33 Governor Macquarie Tower
1 Farrer Place SYDNEY NSW 2000 AUSTRALIA
Telephone: (02) 9228 3344
Facsimile: (02) 9228 3452
e-mail: macdonald.office@macdonald.minister.nsw.gov.au

The Hon Mike Kelly MP
Federal Member for Eden Monaro
PO Box 214
QUEANBEYAN NSW 2620

5 JUN 2009

Dear Dr Kelly

I refer to your representation dated 28 March 2009 on behalf of Mr Robert Bertram, PO Box 161, Bermagui 2546 concerning the Eden Regional Forest Agreement (RFA) and a range of forest management issues in southern NSW.

In his letter Mr Bertram asks whether the State and Federal Governments are in dispute over compliance issues related to the Integrated Forestry Operations Approval (IFOA) for the Eden region and about the management of koalas. It is my understanding that there are no areas of dispute between the Federal and NSW Governments in relation to the Eden RFA. Issues associated with the IFOA under any RFA are managed and regulated by State agencies.

Similarly, issues of koala protection in south coast forests are matters that lie within the responsibility of the State and should be raised with the appropriate State authorities. Forests NSW has advised that information placed before the NSW Scientific Committee indicated there has not been a decline in regional koala populations in recent decades. It should also be noted that a local conservation group strongly supported koalas being listed as an endangered population in the local area in response to a nomination under the *Threatened Species Conservation Act 1995*. The nomination was dismissed by the NSW Scientific Committee in 2007.

Management of koalas is the subject of ongoing research and review, with local communities closely involved in those processes. Forests NSW is working closely with the Department of Environment and Climate Change (DECC) on the Far South Coast Koala Management Framework including liaison on survey techniques on state forest. Forests NSW is exceeding its legal requirements under the IFOA on koala survey techniques and frequency. DECC will consider the survey data and make recommendations to Government regarding any necessary changes to the koala management prescriptions contained within the Integrated Forestry Operations Approval.

In relation to dieback, I am informed that locally it is attributed to either the current drought conditions or an over-abundance of psyllids and bell miners, all of which are evident in the area across all land tenures. Vegetation dieback attributed to psyllids and bell miners has recently been listed as a threatening process across NSW under the *Threatened Species Conservation Act 1995*.

I am also aware that vegetation dieback as a result of both soil based and environmental factors seems to be evident across the broader landscape and is not specifically a local issue. Forests NSW advises that in the Eden area it is particularly associated with private property and national park at the interface of forest and agricultural land. It also occurs in healthy forests as a response to drought, with trees recovering after rain. It is also likely that a lack of low intensity fire induces secondary changes such as increased acidity and aluminium availability that are considered to be harmful to the roots of established trees.

Forests NSW and the Department of Environment and Climate Change are joint sponsors of the Bell Miner Associated Dieback (BMAD) Working Group that is working in a collaborative and coordinated way to address this forest health issue. Forests NSW has established several adaptive management trials under the auspices of the working group in an endeavour to develop a greater understanding of BMAD. The results of these trials will assist in bringing greater clarity and understanding on how to manage Bell Miner Associated Dieback.

The area of Crown land available for forestry operations under the Regional Forest Agreements for both the Eden and the Southern Regions is publically available information and is within the respective Regional Forest Agreements. Access to these are available from the Department of Planning or via the following web sites: www.daff.gov.au ; or www.planning.nsw.gov.au .

For further advice on these matters, please contact Forests NSW Southern region manager, Mr Ian Barnes on 44751400.

I hope this information is of assistance to Mr Bertram.

Yours sincerely



IAN MACDONALD MLC

Appendix 1



Australian Government
Department of Industry, Science,
Energy and Resources

National
Measurement
Institute




REPORT OF ANALYSIS

Page: 1 of 6
Report No. RN1334519

Client : ROBERT GLENN BERTRAM LOT 95 KNIGHTS CREEK ROAD	Job No. : ROBE21/211110 Quote No. : OT-02018 Order No. : Date Received : 10-NOV-2021 Sampled By : CLIENT
Attention : ROBERT BERTRAM Project Name : Your Client Services Manager : TIM REDDAN	Phone : (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
N21/024890	MC1	WATER 02/11/21-1.24 PM
N21/024891	MR1	WATER 02/11/21-1.34 PM
N21/024892	AG1	WATER 03/11/21-8.30 AM
N21/024893	MR4	WATER 03/11/21-8.47 AM

Lab Reg No.		N21/024890	N21/024891	N21/024892	N21/024893	
Date Sampled		02-NOV-2021	02-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MC1	MR1	AG1	MR4	
	Units					Method
Total Recoverable Trace Elements by ICP						
Antimony Total	ug/L	<1	<1	<1	<1	NT2_47
Lead Total	ug/L	<1	<1	<1	<1	NT2_47
Dates						
Date extracted		15-NOV-2021	15-NOV-2021	15-NOV-2021	15-NOV-2021	
Date analyzed		15-NOV-2021	15-NOV-2021	15-NOV-2021	15-NOV-2021	


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Lab Reg No.		N21/024890	N21/024891	N21/024892	N21/024893	
Date Sampled		02-NOV-2021	02-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MC1	MR1	AG1	MR4	
	Units					Method
Miscellaneous						
Conductivity	uS/cm	120	200	340	450	NW_89
Dates						
Date extracted		10-NOV-2021	10-NOV-2021	10-NOV-2021	10-NOV-2021	
Date analyzed		11-NOV-2021	11-NOV-2021	11-NOV-2021	11-NOV-2021	

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National Measurement Institute

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Report No. RN1334519

Lab Reg No.		N21/024890	N21/024891	N21/024892	N21/024893	
Date Sampled		02-NOV-2021	02-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MC1	MR1	AG1	MR4	
	Units					Method



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Report No. RN1334515

Client :	ROBERT GLENN BERTRAM LOT 55 KNIGHTS CREEK ROAD	Job No. :	ROBE21/211110
Attention :	ROBERT BERTRAM	Quote No. :	QT-02018
Project Name :		Order No. :	
Your Client Services Manager :	TIM REDDAN	Date Received :	10-NOV-2021
		Sampled By :	CLIENT
		Phone :	(02) 54450161

Lab Reg No.	Sample Ref	Sample Description
N21/024854	MR5	WATER 03/11/21-8.51 AM
N21/024855	MR6	WATER 03/11/21-9.20 AM
N21/024856	MR3	WATER 03/11/21-9.40 AM
N21/024857	KC1	WATER 03/11/21-12.10PM

Lab Reg No.		N21/024854	N21/024855	N21/024856	N21/024857	
Date Sampled		03-NOV-2021	03-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MR5	MR6	MR3	KC1	
	Units					Method
Total Recoverable Trace Elements by ICP						
Antimony Total	ug/L	<1	<1	<1	<1	NT2_47
Lead Total	ug/L	<1	<1	<1	<1	NT2_47
Dates						
Date extracted		15-NOV-2021	15-NOV-2021	15-NOV-2021	15-NOV-2021	
Date analyzed		15-NOV-2021	15-NOV-2021	15-NOV-2021	15-NOV-2021	



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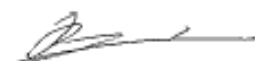
Lab Reg No.		N21/024854	N21/024855	N21/024856	N21/024857	
Date Sampled		03-NOV-2021	03-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MR5	MR6	MR3	KC1	
	Units					Method
Miscellaneous						
Conductivity	uS/cm	220	350	210	250	NW_85
Dates						
Date extracted		10-NOV-2021	10-NOV-2021	10-NOV-2021	10-NOV-2021	
Date analyzed		11-NOV-2021	11-NOV-2021	11-NOV-2021	11-NOV-2021	

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Report No. RN1334519

Lab Reg No.		N21/024894	N21/024895	N21/024896	N21/024897	
Date Sampled		03-NOV-2021	03-NOV-2021	03-NOV-2021	03-NOV-2021	
Sample Reference		MR5	MR6	MR3	KC1	
	Units					Method



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Report No. RN1334519

Client : ROBERT GLENN BERTRAM LOT 95 KNIGHTS CREEK ROAD Attention : ROBERT BERTRAM Project Name : Your Client Services Manager : TIM REDDAN	Job No. : ROBE21/211110 Quote No. : QT-02018 Order No. : Date Received : 10-NOV-2021 Sampled By : CLIENT Phone : (02) 94490161
--	---

Lab Reg No.	Sample Ref	Sample Description
N21/024898	MR2	WATER 03/11/21-12.32PM
N21/024899	PC1	WATER 03/11/21-12.23PM

Lab Reg No.		N21/024898	N21/024899			
Date Sampled		03-NOV-2021	03-NOV-2021			
Sample Reference		MR2	PC1			
	Units					Method
Total Recoverable Trace Elements by ICP						
Antimony Total	ug/L	<1	<1			NT2_47
Lead Total	ug/L	<1	<1			NT2_47
Dates						
Date extracted		15-NOV-2021	15-NOV-2021			
Date analyzed		15-NOV-2021	15-NOV-2021			


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Lab Reg No.		N21/024898	N21/024899			
Date Sampled		03-NOV-2021	03-NOV-2021			
Sample Reference		MR2	PC1			
	Units					Method
Miscellaneous						
Conductivity	uS/cm	210	300			NW_B9
Dates						
Date extracted		10-NOV-2021	10-NOV-2021			
Date analyzed		11-NOV-2021	11-NOV-2021			

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Report No. RN1334519

Lab Reg No.		N21/024898	N21/024899			
Date Sampled		03-NOV-2021	03-NOV-2021			
Sample Reference		MR2	PC1			
	Units					Method



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Total = acid extractable elements



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This Report supersedes reports: *RN1334061* *RN1334484*

Measurement Uncertainty is available upon request.

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